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Editorial Notes

The Research Meeting

THE Autumn Research Meeting of The Institution of Gas Engineers last week gave members and others interested in research aimed at development of the Industry a couple of days of strenuous work and a very great deal to think about. Our special issue to-day, which contains abstracts of the Communications presented and a full report of all the discussions, reflects the extent of the ground covered and should convince anyone who has only a casual acquaintance with the activities of the Gas Industry that it is research-minded in a very real sense. The Industry is gathering the fruits of a far-seeing policy, and we feel sure that the benefits which will accrue from this policy will increase year by year. Our belief in this regard is strengthened by the entry to the Industry of young men trained to a standard of technical competence far higher than formerly—men able to appreciate the significance of research and ready in their attempt to translate into practice the results of this research.

In view of the important announcement made by Mr. H. C. Smith in the course of his Presidential Address to the Institution last June—we refer to the setting up of the Joint Committee of the Institution and the Society of British Gas Industries to examine the whole question of the establishment of a research body with the object of conducting research on co-operative lines—no doubt some little disappointment was felt at the meeting last week with the absence of discussion on policy in this regard. Virtually there was no discussion on the Report of the Research Executive Committee—and, indeed, very little time was allotted to its consideration. Yet the subject of this "research body" must be exercising the minds of all concerned with Gas Industry research. The Report stated that the Executive Committee is considering what steps might be taken to correlate the volume of research work which is already proceeding, to supply what additional effort may be necessary to reinforce any possible weak points, and to provide a means whereby the accumulated and accumulating store of knowledge may be made more readily available for practical application. And Mr. E. V. Evans told the meeting that Dr. Braunholtz had made a survey of research in the Gas Industry and that his report, which was "a most interesting and ably produced document," showed that the Industry—not only the supply side but the side of the plant and appliance manufacturer—was very fully alive. For the time being, then, we leave the "research body," but repeat the remarks of Mr. Smith last June that information concerning it "will be awaited with much interest," while appreciating the necessity, as well as the difficulty, of taking into account and co-ordinating the diverse ideas which are held on the subject before any irrevocable move is made.

It is recognized that joint and co-ordinated work is essential to progress; and the Report of the Executive Committee showed how far the Gas Industry has already travelled in this direction. The contact of the Institution with the universities has become wider, and Mr. Evans said that it was to be hoped that it might be possible in time to build up associations with these other centres of learning as happy and as fruitful as the long association of the Institution with the University of Leeds. Already the Institution has voted funds for supporting five specific investigations. And there can be nothing but gratification with the growing collaboration between the Institution and the Fuel Research Board. This collaboration unquestionably holds out very great promise indeed. Happy features at the meeting were the presentation of a progress report by Dr. J. G. King on work at the Fuel Research Station on gasification and methane synthesis, and of the Paper by Mr. James Jamieson and Dr. King on the production of free burning coke in continuous vertical retorts. The note of co-operation, sounded so often at the meeting, was impressive and encouraging. Then there was such a wealth of evidence of the vast amount of useful and necessary work undertaken by committee after committee on a purely voluntary basis. The Industry is fortunate in the way so many of its members give unstintingly of their services, though one could wish that the burden of committee work was more widely shared.

The high quality of the research work undertaken by the Industry was demonstrated by the Communications circulated at the meeting last week; but, remarked Mr. Evans, so long as the work is conducted in separate laboratories by separate workers, under a direction which is not co-ordinated, there is a risk of overlapping in some directions and of serious gaps in others; but, he added, in this task of co-ordination "care must be exercised to see that whatever is done shall

not disturb that freedom which allows individuality its full play; it is necessary to be adamant about that. It would be a disaster to adopt bureaucratic methods in the control of research work." It will, we are sure, be agreed that research work in the Industry was never on a better footing and the outlook on it never more penetrative and practical. It must have been a matter of the keenest regret to the Institution President, Mr. Robert Robertson, that he was prevented by illness from taking the Chair at last week's meeting, but he has cause for gratification in the interest displayed throughout, as our pages to-day testify, and in the very able manner in which, at very short notice, Mr. George Dixon, the Senior Vice-President, conducted the proceedings. The volume of well-directed research now under way is a happy augury for the future welfare of the Gas Industry.

Gas Sales Again Up

OFFICIAL figures which have just become available show that, from the manufacturing point of view, the year 1937 was one upon which the Gas Industry is fully entitled to congratulate itself; for in the matter of sales, business was good. When the time comes for the financial results to be revealed, increases in costs may be reflected in certain respects which are beyond the control of the Gas Industry, but the main point is that the "business is there."

The gas made (including gas bought from coke ovens) by statutory undertakings during 1937 was 7,936 million cu.ft. (2·4%) more than the quantity for 1936, while the amount sold increased by 6,464 million cu.ft., or 2·1%. A glance at the "JOURNAL" "Calendar and Directory" shows this increase to be well over the total sales of the Manchester Corporation during the same period, and having in mind all the circumstances one is perfectly entitled to regard this result as good, even if not quite so good as would have been the case under more favourable conditions. In the year 1936 the increase in sales of gas over 1935, it will be remembered, was 14,079 million cu.ft., or 4·8%, but that was a better year in some respects than 1937, and the Gas Industry has done well to improve upon the 1936 figures in a period during which, in certain directions, conditions were not quite so good. The total quantity of gas sold in the past year (including gas supplied separately for industrial purposes only) was 316,400 million cu.ft.

This record quantity of gas was disposed of to 11,009,745 consumers, or 234,301 more than in 1936. That was an addition of 2·2% in consumers. There was an increase of 4,504 million cu.ft., or 1·6%, in the amount of coal gas made, but the quantity of water gas sent out showed a small decrease of 99 million cu.ft., or 0·4%. This increase of 1·6% in the make of coal gas was accompanied by an increase of 316,000 tons in the amount of coal carbonized, which reached a total of 18,650,000 tons for the 706 authorized gas undertakings. The quantity of gas bought from owners of coke ovens during 1937, and distributed by these authorized undertakings, was 28,028 million cu.ft., or 3,699 millions more than in 1936—an increase of over 15%. Public lighting obviously retains its favour—and more than retains its favour—with the local authorities, for 1937 witnessed a further increase in the quantity of gas supplied for this purpose, to a figure which has more than doubled itself since the year 1921.

These are some of the outstanding points from Part I. of the Board of Trade Return relating to all authorized gas undertakings in Great Britain for the year 1937, which is reviewed by the "JOURNAL" on later pages of this issue.

The Coke Oven Managers' Association

THE Annual Meeting of the Coke Oven Managers' Association which took place in London on Oct. 27 was devoted, as usual, to the consideration of the business of the Association and to the delivery of the Presidential Address. Sir Thomas Inskip was the chief guest at the Dinner which followed. Mr. J. Curry devoted his Presidential Address severely to a review of the technical and commercial problems of the Industry. The Coke Oven Industry early recognized the importance of properly grading coke for the general market and, with the advantages of coal usually cleaned in washeries under the control of the coke oven manager, and of the possession of central quenching stations equipment, which enabled the moisture content of the coke to be kept remarkably low, they were able to turn out a product which, as we now know from recent work, had just those characteristics which enabled it to compete with the more combustible gas cokes made at works not possessing these advantages. Since then there have been developments in the art of coal blending, and although a good deal more could be done in this direction than is being done at the moment, there can be no doubt that the coke oven can (not necessarily does) turn out a product which is as combustible as that from gas retorts.

An advantage possessed by the Gas Industry but denied to the coke ovens is the possession of the vertical retort in which, as has just been shown by Mr. Jamieson and Dr. King, weakly-caking coals can be carbonized with the production of excellent domestic fuel. So long as the colliery interests believe that the prime purpose of the by-product coke oven is to carbonize slack coal, the coke ovens will not feel this disadvantage, but if, as seems probable, a large proportion of the coke oven industry turns wholly to the provision of fuel for the general coke market, we may yet see the introduction of the vertical retort into the by-product coking industry. There are already in existence at Whalley Gas-Works chamber ovens which for all practical purposes are vertical coke ovens equipped with generators and using dust-free cleaned gas. Paradoxical as it may sound, we have heard whispers that the coke oven industry is not irrevocably wedded to coke ovens, but is prepared to erect other types of plant, including low-temperature retorts that can produce coke of the desired character.

Quality and Grading

THESE possibilities must be read in conjunction with Mr. Curry's remark that: "We must, at all times, look to the quality of our products and not think in terms of highest yields of by-products obtainable to the detriment of coke quality. Coke is the major product and, if the demand be for home or export trade, the quality factor should always be met. In the export market British cokes are in competition with many foreign makes, and we must dismiss from our minds that British coke is always on top. Our Continental friends have nothing to learn in the art of coke making and marketing their products in the right condition."

A point of practical importance is in regard to grading in which Mr. Curry believes that some international standard should be adopted. In this country most of the screening at coke ovens is done over various sizes of square mesh holes, and the products are classed as $\frac{5}{8}$ to $1\frac{1}{2}$ in., $1\frac{1}{2}$ to $2\frac{1}{2}$ in., and $2\frac{1}{2}$ to $3\frac{1}{2}$ in., whereas our Continental competitors in the export

market screen over round hole mesh of various sizes and call their products Nos. 1, 2, and 3, which Mr. Curry believes to be a much simpler method.

The tar and pitch markets caused Mr. Curry some uneasiness and it is, of course, well known that pitch is the black spot in the tar distiller's field of vision in more senses than one. Pitch for the briquette market in this country is almost of no account. It is true that in the export market increasing quantities have been shipped during the past three years, but not to the same extent as the increased production. Some pitch coke has been manufactured and marketed in competition with petroleum coke which is always a step in the right direction, although large quantities of pitch are still being burnt as boiler fuel at very low prices, and new markets are necessary, otherwise we shall often be faced with these fluctuations. Readers may remember that in the spring of this year an interesting Paper was read by Mr. Leon B. Jones and Mr. G. M. Gill before the Institute of Fuel in which they described a process for the production of gas similar in composition to coal gas, but manufactured from petroleum residues. This process is a combination of cracking with treatment by steam for the production of water gas, no solid residue remaining. A good many of these plants are in operation in the U.S.A., and one is being built in this country at a gas-works. The possibility of using the plant described by Messrs. Jones and Gill to manufacture gas from pitch has already been ventilated in the by-product coking industry. No doubt the Gas Industry is watching developments.

Co-operation

MR. CURRY noted that coke oven gas for domestic use continues to make progress and that the gas companies' industrial load is rapidly expanding. South Yorkshire has made full use of the gas grid and he would like to see much more done in other parts of the country on similar lines. In pursuance of this theme, attention should be drawn to the admirable remarks of Mr. George Dixon, who represented The Institution of Gas Engineers at the Dinner. He said that there had been a great deal of talk going on for a considerable time upon the subject of co-operation and that he himself was getting tired of it. He believed that the time had come for action, and that the two industries should get together to pool their resources in the light of modern research. Men of good will on both sides are endeavouring to hammer out methods of co-operation in the field of coke disposal. This is the first step and if it is successfully taken, who knows how far it may lead us? It is impossible to prophecy regarding the future because it may well be that the research upon the new gas-making process at Leeds University will eventually show the Gas Industry the way to make cheap gas without the concurrent production of coke. If gas can be made cheaply enough by this process to enable solid fuel to be completely displaced by gaseous fuel there can only be co-operation with the coke oven industry in regard to gas because the Gas Industry will cease to purvey coke. If, on the other hand, the new process does not lead to such cheap gas that people can do without coke altogether, the adoption of a total gasification process by the Gas Industry would lead to still greater collaboration with the coke oven industry, since the one would provide gas and the other coke. All this is a dream of the distant future, but sometimes "the farthest flights of fancy have a way of becoming true."

Meanwhile, the gas and coke oven industries together carbonize about 40 million tons of coal annually, which, as Mr. E. V. Evans has shown, has a real equivalent in use of perhaps 50 million tons. They cater partly for the same public and they sell partly to the same industries. They put about 140,000 miners in work to get their coal. There is between the two industries a great community of interests. If we neglect coking plants situated at steel works, which may well become a branch of the industry that follows another road ever diverging more from the remainder of the industry, the community of interests is so great as to be almost identical. It would be identical if it were not that the policy of the coking industry must of necessity be dictated by the coal owners, or at least by that section of the coal owners which owns coke ovens. There is on this account some slight divergency of aims; but nothing that need prevent means being found for that close co-operation to which Mr. Dixon looks forward. The feeling is widespread, and we believe it is held by the more scientifically minded in the coal industry also, that prepared fuel is more economical than raw coal for very many purposes. It is the joint duty of the gas and the coking industries to prepare for efficient public consumption the raw fuel which the coal owners bring to the surface. In that there lies a truly common purpose, towards which methods of the closest co-operation, of taking joint counsel together, can surely be found.

Forthcoming Engagements

November.

10.—G.C.P.A.—Committee Meeting, 5, Victoria Street, S.W. 1, 2.30 p.m.

12.—Scottish Western Juniors.—Address by W. R. Drummond on "The Work of the National Gas Organizations in Scotland."

12.—Yorkshire Juniors.—Meeting at Sheffield. Presidential Address by A. Wylie.

15.—B.C.G.A.—Yorkshire District Meeting, Leeds.

15.—B.C.G.A.—South-Western District Meeting, Exeter.

16.—Southern Association (Eastern District).—Meeting at Gas Industry House, 2.30 p.m. Paper on "Framing a Sales Policy from Market Research."

16.—Manchester and District Juniors.—Visit to Victory Works of Parkinson & Cowan (Gas Meters), Ltd., Stretford. Paper by F. Bell on "Installation of Gas and Steam Equipment in a Municipal Kitchen."

17.—Midland Juniors.—Visit to John Harper & Co., Ltd., Willenhall.

18.—I.G.E.—Session at Public Health Exhibition, Agricultural Hall, Islington, 3 p.m.

18.—North of England (Auxiliary) Association.—Half-yearly Meeting at Newcastle-upon-Tyne, 2.30 p.m. Paper by J. S. Merry on "Boiler Water Problems."

18.—Southern Association (Western District).—Commercial Meeting, Rougemont Hotel, Exeter, 2.30 p.m.

19.—Western Juniors.—Visit to Portishead Generating Station, Bristol. Paper by H. C. Widlake, of Plymouth.

21.—L.C.C.A.—Finance Committee, 10.45 a.m.; Executive Committee, 11.45 a.m.; Central Committee, 2.30 p.m.

25.—Southern Association.—General Meeting, Hotel Victoria, Northumberland Avenue, W.C. 2, 2.15 p.m. Paper by S. F. Dunkley on "Quality Control and a System in Operation." Committee Meeting, 11.45 a.m.

25.—London and Southern Juniors.—Annual Dinner and Concert, Empire Restaurant, Victoria, S.W. 1.

26.—Scottish Western Juniors.—Visit to Greenock Corporation Gas Department.

(There will be no meeting of the Central Executive Board of the National Gas Council or of the Central Committee of the Federation of Gas Employers during the Month of November.)

December

1.—Midland Juniors.—Paper by F. A. C. Pykett, "The Distribution of Gas at Coventry."

2.—I.G.E.—Joint Committee on Complete Gasification under Pressure, 3 p.m. *(Transferred from Dec. 8.)*

3.—Manchester and District Juniors.—Meeting at Blackburn. Paper by E. B. Field on "Advantages and Disadvantages in the Production and Distribution of a Low-Quality Gas."

News of the Week

A Donation of £100 has been given by the Derby Gas Light and Coke Company to the Bishop of Derby's Appeal Fund for Church Expansion in the diocese.

A Second Prize in the "Things for Service" class in the window display competition held in connexion with the Plymouth and Devonport Shopping Festival last week was won by the City Gas Department with a display at Fore Street, Devonport.

One of the Judges for a window dressing competition organized by the Hatfield Chamber of Trade for local shopkeepers was Mr. W. R. Oliver, Display Officer of the British Commercial Gas Association and Past-Chairman of the National Display Association.

Excellent Attendances were recorded at a series of cookery demonstrations which was recently held in the showrooms of the Glasgow Corporation Gas Department, in collaboration with the Parkinson Stove Company. Cookery demonstrations were given daily by Miss Barbara Cobb, *Diplomée*, N.C.D.S., on the "Renown" cooker, and in the showrooms there was arranged a comprehensive display of Parkinson appliances, a feature of which was the "Renown" gas cooker.

A Striking Window Display was arranged recently in the showrooms of the Sunderland Gas Company. The theme of the display was "How Gas Helps Industry in Sunderland," and the remarkable number of different objects included in the window spoke volumes for the service of the Undertaking and for the reliance which is placed on gas by Sunderland industrialists. Here is a selection of the widely differing trades and industries represented in the display: Disinfectants, cattle-foods, galvanizing, mineral waters, paints and varnishes, book-binding, brushes, confectionery, pipe-bending, garden lime, malt roasting, cycle lighting sets, steel-cutting, embossing leather, sauce and pickles, files, glassware, and many more. The display aroused considerable local interest.

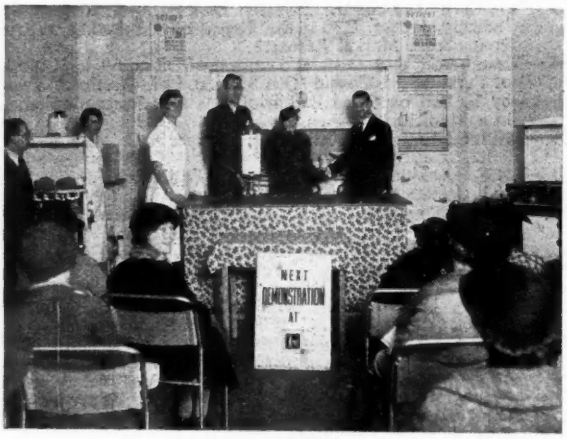
A Cheque for £104 has been handed over to the Local Infirmary Gala Committee by the Worcester New Gas Light Company as a result of the sale of "hot dogs" and balloons during the recent Infirmary Gala.

A Series of Cookery Demonstrations which was recently held at the Tunbridge Wells Gas Company at the Girl Guides' Hall, Crowborough, proved highly successful, and resulted in good business. The cookery lectures were given by Miss P. Allen, *Diplomée*, N.S.T.C.D.S., of the Parkinson Stove Company, Ltd., on a "Renown" gas cooker. Very good attendances were recorded.

During the Past Three Weeks 914 cups of tea were served from the "Ascot" tea bar exhibited at the Worcester New Gas Light Company's showroom, to demonstrate the use and advantages of the Ascot Gas Water Heater Company's boiling water appliance. "Judging from the actual sales and the number of enquiries we had," Mr. George P. Mitchell, Engineer and General Manager, writes, "this form of advertisement has certainly left its impression on the minds of our consumers."

A Supply, on the basis of a guaranteed consumption of 2 million cu.ft. per annum, has been offered by the Airdrie Gas Department to Crimpy Crisps, Ltd. Should this quantity not be consumed the Company will have the option of paying for what is used at the ordinary industrial rate or making up the difference in cost to 2 million cu.ft. Should the offer be accepted by the Company, Mr. A. Kellock, the Engineer and Manager, has been authorized to lay a new six-inch main to the factory. It will be 261 yd. long and will cost £215. In view of negotiations with the Coatbridge Gas Company for the sale of the Undertaking, Mr. Kellock and the Town Chamberlain have been instructed to prepare a statement giving the Undertaking's financial position and other data as at Nov. 15. Pending the result of negotiations Mr. Kellock has been authorized to carry out any necessary maintenance repairs at the Airdrie Works.

The Twelve-Millionth Visitor



The twelve-millionth visitor to the Empire Exhibition at Glasgow was presented with an "Ascot" gas water heater. Here we see the presentation to Mrs. Wilson being made by Mr. W. R. Oliver, Display Officer to the B.C.G.A., while included in the group are Mr. C. H. Busby, Scottish Manager of Ascot Gas Water Heaters, Ltd., and Miss Sketchley, of the Forth and Clyde and Sunnyside Iron Company, Ltd., the demonstrator.

British Commercial Gas Association

New Executive Chairman

Mr. H. D. Madden, Engineer and Manager of the Cardiff Gas Light and Coke Company, has been elected Chairman of the Executive Committee of the B.C.G.A. in succession to Mr. W. J. Sandeman, on the expiry of the latter's year of office.

Personal

At the Watford Municipal Elections Mr. E. T. WARREN, Assistant Secretary of the Watford and St. Albans Gas Company, was returned unopposed as the Conservative Member for the Cassiobury Ward.

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Mr. WILFRID HAWORTH, who for the last three years has been Works Superintendent to the Ulverston U.D.C. Gas Department, has been appointed Manager of the Gas and Water Departments of the East Dereham U.D.C. He had, previous to his appointment at Ulverston, held similar positions at Ripon for five years and Oswaldtwistle for four years.

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Mr. THOMAS E. PARRY, B.Sc., Assistant Engineer and Manager to the Bingley U.D.C. Gas Department, has been appointed Engineer and Manager to the Fleetwood Gas Company. He will take up his duties on Dec. 1, succeeding Mr. W. P. SMITH, B.Sc., who has been appointed Assistant Engineer and Manager to the Rochdale Corporation Gas Department.

Obituary

The death occurred on Sunday, Oct. 23, of Mr. WILLIAM HENRY WAYTE, who was for thirty-five years Distribution Superintendent at the Norwich Station of the British Gas Light Company.

Mr. Wayte received his early training with the West Bromwich Corporation Gas Department, was later at Newcastle-on-Tyne, and was appointed at Norwich in 1903. He was an Associate Member of The Institution of Gas Engineers and was responsible for a number of patented appliances and improvements in gas apparatus.

The cremation ceremony, at which many of his colleagues and friends were present, was at the Crematorium at St. Faith's, near Norwich, on Oct. 25.

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The death occurred at the Tower, Kenley, Surrey, on Oct. 30, of Mr. EDWARD BROTHERTON-RATCLIFFE, son of the late Mr. Frederick Edwin Ratcliffe and the late Mrs. Brotherton-Ratcliffe, and brother of Mr. Charles Brotherton, of Kirkham Abbey, Yorkshire. He was 53, and leaves a widow, five sons, and two daughters. The eldest son, Mr. Edward Brotherton-Ratcliffe, Jnr., is with Messrs. Brotherton & Co., Ltd., at their Cheshire Works. Mr. Edward Brotherton-Ratcliffe founded the firm of Brotherton-Ratcliffe & Co., Ltd., chemical merchants.

The British Gas Federation

Annual General Meeting

The Fourth Annual General Meeting was held at Gas Industry House on Nov. 2, Sir DAVID MILNE-WATSON, Bart., LL.D., D.L., presiding.

The minutes of the Third Annual General Meeting held on Nov. 3, 1937, having been circulated, were taken as read, confirmed, and signed.

The Chairman expressed regret that Mr. Robert Robertson, President of The Institution of Gas Engineers, was unable to be present through illness, and wished him a speedy recovery.

Among other apologies for absence were the following: Messrs. Wm. Cash, R. Halkett, S. E. Halliwell, W. Muter, A. M. Paddon, T. P. Ridley, C. S. Shapley, J. Sandon Stubbs.

The Annual Report was then presented.

The CHAIRMAN remarked that the Report had been circulated and that it was proposed to send 100 copies to the Secretaries of the constituent bodies for distribution to their members, following the usual practice. He then moved the adoption of the Report and Accounts.

Mr. A. W. SMITH (Birmingham) seconded and at the same time, in the absence of Mr. William Cash, gave a brief explanation of the accounts.

The CHAIRMAN said everybody would be extremely pleased to hear that the sum of over £19,000 had been promised in connexion with the permanent Gas Gallery at South Kensington. The Federation very much appreciated what had been done by the Society of British Gas Industries, which promised £5,000 but had very generously exceeded that amount.

The Fourth Annual Report and Audited Statement of Accounts for the period ended Sept. 30, 1938, were then unanimously approved and adopted.

The list of members nominated by the constituent bodies to the Council under Rule VI for the year commencing on Jan. 1, 1939, as set out in the Report, was reported to the meeting, viz.:

REPRESENTING NATIONAL GAS COUNCIL.

Sir David Milne-Watson, Bart., LL.D., D.L.	T. P. Ridley
Wm. Cash, J.P.	C. S. Shapley
	A. W. Smith

REPRESENTING BRITISH COMMERCIAL GAS ASSOCIATION.

A. M. Paddon	James Jamieson
W. J. Sandeman, J.P.	J. Sandon Stubbs
S. E. Halliwell	

REPRESENTING INSTITUTION OF GAS ENGINEERS.

George Dixon	H. C. Smith
Stephen Lacey	Sir Frederick J. West, C.B.E., J.P.
R. Robertson	

REPRESENTING GAS COMPANIES' PROTECTION ASSOCIATION.

C. M. D. Belton	F. G. Brewer
H. E. Bloor	R. Halkett
Chas. F. Botley	

REPRESENTING SOCIETY OF BRITISH GAS INDUSTRIES.

Col. O. B. F. Planck, D.S.O., T.D., D.L.	R. J. Rogers
F. B. Richards, M.B.E.	H. M. Thornton, J.P.
	Ernest West

On the motion of Mr. J. JAMIESON, seconded by Mr. H. E. BLOOR, the election of Mr. Alfred Morland, F.C.A., as auditor for the ensuing year was unanimously approved.

This concluded the formal business of the meeting.

Colonel O. B. F. PLANCK (Chairman of Council, Society of British Gas Industries), proposing a vote of thanks to Sir David Milne-Watson for presiding at the meeting, said that everybody was well aware that the Federation owed its formation more to Sir David than to anyone else, and it was a great pleasure to see him again in the Chair that afternoon on the occasion of the Fourth Annual Meeting. It had been very satisfactory to hear what Sir David had said with regard to the large sum that had been promised in connexion with the permanent Gas Gallery at South Kensington. Undoubtedly this was going to be of educational value for many years, and it was an example of the great benefits that resulted from collaboration between all sections of the British Gas Federation.

The vote of thanks was carried with hearty acclamation and the meeting closed.

Gas Statistics for 1937

Particulars relating to the manufacture and supply of gas during the year 1937 by all authorized gas undertakings in Great Britain are contained in the Board of Trade Return. This Return (which is published by H.M. Stationery Office, York House, Kingsway, W.C. 2, at the price of 4s. 6d. net, postage extra) includes statistics regarding 706 undertakings.

There is a continuation of a tendency which has prevailed for a good many years past—that is, for a number of undertakings included to diminish. This time the fall is from 714, so that over the year the number has been reduced by eight. As recently as 1920 there were 798 of these authorized gas undertakings. The falling off of eight undertakings during 1937 is a net reduction, inasmuch as five additions were made to the Return, which were an off-set to the results of the process of absorption. Several undertakings changed ownership while retaining their individuality—including three which passed from municipal to company ownership.

More Gas Sold.

The figures in the comparative table which accompanies this article show that there was an increase in the quantity of gas sold by these undertakings of about 6,464 million cu.ft. over the total of 1936—that is to say, from 309,936,000,000 cu.ft. to 316,400,000,000 cu.ft., these figures including gas supplied separately for industrial purposes only. The quantity of gas made (including that bought from coke ovens) during 1937 was 7,936 million cu.ft., or 2·4%, more than the make in 1936, while the sales were 2·1% greater. Not so big a gain as in 1936, when an increase in sales of 4·8% was registered, but better than 1935 with its increase of 1·8%, or the 1·6% gain of 1934.

Reference has been made to the fact that these figures include gas supplied separately for industrial purposes only. There are five undertakings which so supply gas through a separate main, and between them they contribute 8,036,938,000 cu.ft. to the total. More than three-quarters of the amount is sent out by the South Staffordshire Mond Gas Company, the Swinton and Mexborough Gas Board coming next with 647,782,000 cu.ft., and the Sheffield Gas Company with 564,260,000 cu.ft. The others are the Rotherham Corporation (437,657,000 cu.ft.) and the Wombwell Urban District Council (26,477,000 cu.ft.). There was no increase during the year in the number of undertakings so supplying industrial gas, but the quantity sent out is a growing one; the figure of 8,037 million cu.ft. on the present occasion comparing with 7,774 millions in 1936 and 6,445 millions in 1935.

Coke Oven Supplies.

It will have been noted that the quantity of gas sold in 1937—316,400 million cu.ft.—includes that bought from coke ovens. Here, again, one meets with steadily increasing figures. The table reproduced shows that the quantity of gas bought from owners of coke ovens during 1937 and distributed by authorized gas undertakings was 28,028 million cu.ft., or 3,699 million cu.ft. (15·2%) more than in 1936, when the figure was 24,329 millions. In 1935 the total was little more than 20,000 million cu.ft. By the end of 1937 the number of purchasing undertakings had been increased to 45—five more than in the preceding year. The new coke oven gas purchasers are the Barnsley Gas Company, the Bishop Auckland District Gas Company, the Darlington Corporation, the Newport (Mon.) Gas Company, and the Spennymoor and Tudhoe Gas Company. The Sheffield Gas Company remain by far the largest purchasers of coke oven gas, with a total of 10,058 million cu.ft., while the Newcastle-upon-Tyne and Gateshead Gas Company come next with 3 861 millions. The other undertakings purchasing over 1,000 million cu.ft. of this gas were the Derby Gas Light and

Coke Company, the Middlesbrough Corporation, the Rotherham Corporation, and the Stoke-on-Trent Corporation.

Some Working Figures.

Turning again to the comparative table, it is seen that there was an increase of 4,504 million cu.ft., or 1·6%, in the quantity of coal gas made, and that the quantity of coal carbonized (18,650,000 tons) was 316,000 tons more than in 1936. On the other hand, there was a small decrease of 99 million cu.ft., or 0·4%, in the quantity of water gas made in separate generators, which totalled 27,359,581,000 cu.ft. This, with the 279,453,806,000 cu.ft. of coal gas, resulted in a total make of 341,985,000,000 cu.ft.—including the output of the South Staffordshire Mond Gas Company, certain small quantities of "other gas," and the coke oven gas purchased. Some 15,000 tons less of coke and about 385,000 gallons more of oil were used in the manufacture of water gas than in 1936. The quantity of coke and breeze made in 1937 increased by 228,000 tons, while the make of tar was greater than in 1936 by 3,127,000 gallons. There was also an increase of 612 tons in the amount of sulphate of ammonia produced. In the comparative table, under the section showing "Quantity of Residuals Made," in the column "Sulphate of Ammonia" the actual make of sulphate is given in italics. The roman figures indicate the equivalent number of tons of sulphate represented by ammoniacal liquor produced (but not converted into sulphate), where this figure is given by the undertaking.

In the body of the Return details are furnished of the number of therms sold, based on the declared calorific value in the case of undertakings authorized to charge on a thermal basis, and the number of therms sold by those undertakings during 1937 was 1,494,324,122. In the case of undertakings not so authorized (with the exception of the Sharpness and South Staffordshire undertakings, to which the thermal provisions of the Gas Undertakings Acts are not applied, and the Portsoy Corporation, who supply acetylene gas), an estimated figure, based on a calorific value of 500 B.Th.U., has been inserted in the Return, and the number of therms as so estimated amounts to 2,059,834.

COMPARATIVE TABLE.

Year.	Number of Authorized Undertakings Included in Return.	Quantity of Gas. Made. Gas from Carbonization of Coal.	Made. Water Gas in Separate Generators.	Made. Total Made.	Sold. To Local Authorities for Public Lamps.	Sold. To Prepayment Consumers.	Sold. To Other Consumers.	Sold. Total Sold.	Length of Gas Mains.
		1,000 Cu.Ft.	1,000 Cu.Ft.	Million Cu.Ft.	1,000 Cu.Ft.	1,000 Cu.Ft.	1,000 Cu.Ft.	Million Cu.Ft.	Miles.
1932	734	251,018,508	38,468,132	309,336*	12,130,576	109,974,360	164,883,077	286,988	53,156
1933	727	249,179,563	39,236,880	309,557*	12,242,631	111,666,260	162,235,458	286,144	54,916
1934	726	257,118,239	32,610,918	313,546*	12,640,257	112,481,528	159,998,266	290,664†	56,928
1935	718	260,505,328	32,354,744	319,342*	13,306,742	113,171,813	162,932,730	295,857†	59,010
1936	714	274,949,811	27,458,821	334,049*	13,907,828	116,608,661	171,644,865	309,936†	61,593
1937	706	279,453,806	27,359,581	341,985*	14,482,866	118,067,959	175,810,559	316,400†	63,436

Year.	Materials Used in Making Gas. Coal Carbonized.	Materials Used in Making Gas. Coke for Water and Producer Gas.	Materials Used in Making Gas. Oil for Carburetting.	Quantity of Residuals Made. Coke and Breeze.	Quantity of Residuals Made. Tar.	Quantity of Residuals Made. Sulphate of Ammonia.	Number of Consumers. Prepayment.	Number of Consumers. Ordinary.	Number of Consumers. Total.
	1,000 Tons.	1,000 Tons.	1,000 Gallons.	1,000 Tons.	1,000 Gallons.	Tons.			
1932	17,001	746	51,749	11,416	211,010	*75,728*	5,783,449	3,989,566	9,773,015
1933	16,714	749	54,139	11,090	209,983	*65,827*	6,017,383	3,994,996	10,012,379
1934	17,137	620	40,296	11,396	215,966	*71,140*	6,312,760	3,964,250	10,277,010
1935	17,294	640	41,679	11,541	219,774	*76,701*	6,559,123	3,957,636	10,516,759
1936	18,334	545	32,507	12,286	233,656	*86,345*	6,802,523	3,972,921	10,775,444
1937	18,650	530	32,892	12,514	236,783	{94,188} {*86,957*}	7,007,204	4,002,541	11,009,745

* Including "Other Gas" and "Coke-Oven Gas." † Including "Gas supplied separately for industrial purposes only."

Coke Oven Gas Purchased.

The following is a comparative table of the quantities of gas bought from owners of coke ovens by authorized gas undertakings in Great Britain during the years 1932 to 1937:

Year.	Number of Purchasing Undertakings.	Quantity of Coke-Oven Gas Bought.
		1,000 Cu.Ft.
1932	32	15,441,487
1933	31	16,326,786
1934	33	18,194,054
1935	40	20,454,577
1936	40	24,329,216
1937	45	28,028,288

More People Use Gas.

The Return for 1937 sums up one of its most vital aspects with the remark that the number of consumers increased by 234,301, or 2·2%. So that, in spite of all the efforts of enterprising competitors, more people than ever before are using gas. In fact, one should say "more and more," for in this respect each Return as it comes along presents a new record. Now the consumers of the authorized gas undertakings of Great Britain have passed the eleven million mark. The ten million stage was reached in 1933, and the nine million in 1929. On the present occasion, the increase of 2·2% in the number of consumers accompanies an increase of 2·1% in the amount of gas sold; whereas for 1936 there was a gain of 2·5% in consumers side by side with an increase of 4·8% in the quantity of gas sold. Thus in this respect 1936 was appreciably better than 1937. At the same time, 1935 was not so good as either year, for then an increase of 2·3% in the number of consumers coincided with an increase of only 1·8% in the total quantity of gas sold. In 1936 there was a big jump in the quantity of gas supplied separately for industrial purposes through a special main, whereas last year, though there was once more a substantial gain, it was nothing like the same proportions. Besides these special industrial supplies by five undertakings, practically every concern sells some of its gas output for purposes of trade and industry, and the proportion is constantly growing. Therefore it must be expected that the consumer and sales figures will be increasingly influenced by the state of business throughout the country. This fact renders all the more desirable every possible effort to increase the uses of gas among private consumers. As was remarked in the "JOURNAL" editorial columns a year ago, when all things are considered, "there remains plenty of room for still further improvement in the consumption per consumer figure, and to secure this we know that the Gas Industry will continue to put forth its best efforts."

The prepayment meter continues to enjoy popularity to an ever-increasing degree, until now round about two-thirds of the total number of consumers are supplied through these meters. In fact, since 1920 this class of consumer has grown in numbers from four millions to seven millions, while over the same period the ordinary consumers, who now number just over four millions, have added but little more than half-a-million to their numbers. During the year 1937, nearly 2,000 miles of additional gas mains were provided, making a total of 63,436 miles, to supply the 11,009,745 consumers.

Public Lighting by Gas.

Just a word or two before closing with regard to the quantity of gas sold to local authorities for use in the public lamps. Since 1921 this figure has more than doubled, until, as will be seen from the comparative table, it has now reached 14,482,866,000 cu.ft. This represents a percentage of the total sales that is by no means unworthy of consideration, apart altogether from the value of public gas lighting from what may be termed the "demonstration point of view." That the lighting of street lamps by gas continues to grow in popularity at so satisfactory a rate is a comforting reflection for the pedestrian who may be confronted at times by certain other styles of illumination. The Gas Industry must continue to strengthen its hold on the public lighting load,

THE "JOURNAL" REVIEW

OF THE

Institution Research Meeting

Held at the Institution of Mechanical Engineers, London.

Nov. 1 and 2

THE opening session of the Tenth Autumn Research Meeting of the Institution of Gas Engineers commenced on the Tuesday morning of last week with Mr. George Dixon, of Nottingham, the Senior Vice-President, in the Chair. At very short notice Mr. Dixon had been asked to preside at the meeting owing to an attack of influenza which unfortunately prevented the President, Mr. Robert Robertson, from being present throughout. A telegram of regret and good wishes was sent to Mr. Robertson, and those attending were gratified to learn at a later stage in the meeting that he was making a good recovery.

The notice convening the meeting having been read by the Secretary, Dr. W. T. K. Braunholtz, a welcome was extended to overseas visitors—Mr. C. G. Driessen, of the Maastricht Gas Undertaking, Holland; Mr. T. B. Glover, of the Primitiva Gas Company of Buenos Aires; and Mr. J. Howard Goldsmith, of the South African Lighting Association.

Research in General.

THIS brought us to the first item on the agenda—presentation of the 4th Report of the Research Executive Committee, 1937-38. In the course of his remarks in introducing the Report Mr. E. V. Evans, Chairman of the Committee, spoke of the wider contact of the Institution with the universities as research centres and expressed the hope that in time associations may be built up with these other centres of learning as happy and as fruitful as the long association with the University of Leeds. He spoke, too, of the close collaboration with the Fuel Research Board. "Such joint and co-ordinated work," he remarked, "is essential to progress, and I can promise you that there is to be a great deal more of it in the future." He explained that Dr. Braunholtz had recently made a survey of research in the Gas Industry. The report, which was a most interesting and ably produced document, showed that the Industry—the supply side and also the plant and appliance manufacture—was fully alive. "That there is a large volume of work of excellent quality being done," continued Mr. Evans, "is shown by the reports circulated to this and to other research meetings, but so long as the work is conducted in separate laboratories by separate workers, under a direction that is not co-ordinated, there is a risk of overlapping in some directions and of serious gaps in others. Of necessity the research staff of a gas undertaking or of a manufacturer of plant or appliances is largely concerned with problems of immediate interest to that business, but out of such studies there will, from time to time, arise observations of wider importance but of less obvious significance. In the press of more urgent work such observations may be shelved, but it would be far better if they could instead be brought to the notice of those who may have more time and facilities to develop further such observations.

"Co-ordination of some kind would appear to be urgently necessary but we must be careful to see that whatever is done should not disturb that freedom which allows individuality its full play. We are most adamant about this. It would be a disaster to adopt bureaucratic methods in the control of research work, and it is clearly undesirable to hamper any worker from acquiring an advantageous competitive position for his employer." In his concluding remarks Mr. Evans paid high tribute to the work of Professor Cobb and offered a welcome to his successor in the Livesey Chair, Dr. D. T. A. Townend.

The only speaker in the discussion was Colonel W. M. Carr, who put forward the suggestion that practical collaboration with the Institution of Heating and Ventilating Engineers might be introduced on the question of efficiencies of various fuel consuming appliances.

Effluents and Ammonia.

THE publication was then reported of a book on "Gas-Works Effluents and Ammonia" by Dr. A. Key, Research Chemist to the Institution. Mr. C. F. Botley, Chairman of the Committee which has produced the volume, explained that it was the result of many years work in connexion with liquor effluents and ammonia problems, and he urged everyone to make sure of having a copy in his library. The publication, he said would prove of incalculable value to all who consulted its pages.

All About "A.T.B."

THERE followed the "A.T.B." report—or, more correctly, the "42nd Report of the Joint Research Committee of the Institution and Leeds University. Combustion Characteristics of Town Gas—Part III. Properties and Method of Use of the Aeration Test Burner (Model A)." This described the precautions to be observed in the use of the burner, its constructural details, and method of calibration. The consistency of the readings of the burner over a prolonged period and the effect of atmospheric pollution on such readings are described in detail, while the effect of varying humidity has been noted. Following this detailed study of the action of the burner results are given for the A.T.B. number of a town gas supply. Presenting the report, Mr. H. C. Smith, Chairman of the Joint Research Committee, remarked that those members of the Institution who appreciated the assistance and control of manufacturing processes which would accompany the use of an apparatus capable of indicating quickly and reliably the suitability of a gas or mixture of gases for use on appliances might perhaps be a little disappointed that the Committee was not able to announce in the report that such an apparatus was now available and that it was reliable in use. Unfortunately, a very large number of experiments had shown that minute differences arising out of both the construction and maintenance of the aeration test burners, in their methods of use, and in atmospheric conditions had been sufficient to upset any attempt to correlate the results obtained from different burners made to the same specification and operated as nearly as can reasonably be expected in the same manner. He thought that the results of experience which are being accumulated in different parts of the country on the performance of aeration test burners might, with great advantage, be communicated directly to the Research Chemist Mr. Wood. The latter, who introduced the report, remarked that, having brought the test burner to a reasonable degree of consistency in reading, the next and most important phase of the work is to ascertain to what extent the purely empiri-

cal readings quantitatively indicate the behaviour of gases in ordinary appliances, both domestic and industrial, and experimental work in this direction is already in hand. In this connexion he also expressed the hope that those engineers who have used the Aeration Test Burner will continue to do so, and that they will render a service to the Industry by communicating their experiences to him. The production of gas within close limits of A.T.B. Number, he added, does not necessarily involve special supervision, though one undertaking finds it necessary to take special measures to maintain a uniform A.T.B. Number, but claims that the effort is well worth while.

Question of Calibration.

DISCUSSION on the report was opened by Professor D. M. Newitt, who suggested that, in spite of what has been said on the subject of turbulence, the condition one wants to arrive at in the burner is a purely streamline condition, and that one ought to be satisfied to obtain mixing not by turbulence but by a process of diffusion as the gas goes up the tube. He also suggested, in regard to periodic calibrations of the burner, that some standard gas mixture might be used to check from time to time. Mr. F. O. Hawes mentioned that he had been attempting to devise some standard of measurement by using mixtures of pure gases and submitted that such a standard is not impossible of attainment and is highly desirable. Mr. L. T. Minchin maintained, however, that it is very difficult to get a really accurate mixture of pure gases, and explained that at Watson House a gas of known specific gravity is employed and the air-gas ratio of the burner is measured. All the same, he thought a still better method should be introduced. An interesting contribution to the discussion was made by Mr. A. Forshaw, who said that, while we are hearing of this great accuracy in the A.T.B. number, the appliance maker is given a limit of something between 60 and 90 A.T.B. number in the burners he has to reproduce for the public. Winding up the discussion, Mr. G. C. Holliday remarked that working to narrower limits may restrict flexibility at some gas manufacturing stations, but against this must be balanced the savings in maintenance and adjustment of appliances and the better and more constant standard of service now demanded by the consumer.

Rules for Safety.

THE 1st Report of the Gas Works Safety Rules Committee was then introduced by Mr. F. M. Birks. This contained voluntary rules for the safe operation of purifiers and in addition recommendations and reports dealing, *inter alia*, with the corrosion of gasholder sheeting, anti-freezers causing siphoning of sealing water from cups of water sealed holders, respirators for carbon monoxide, testing of gas-works valves, exemptions from the Factories Act, 1937, gasholder record sheets, and air raid precautions.

In the discussion on the report, the first speaker, Mr. A. H. Andrews deprecated the use of the word "voluntary". "I think", he said, "that the operations are so important and the risks involved so serious that the average gas engineer should be impressed to adopt a uniform practice". Mr. Andrews, saying he had no objection to any of the draft rules laid down in the report, explained in what particulars the practice of the South Metropolitan Gas Company differs. He stressed the great importance of regularly testing and inspecting gas-works valves. In his opinion the purging of plant and apparatus did not receive in the report the importance it deserves. Purging by inert gases was, he said, something new to the Industry, but it was a measure of safety which must be widely adopted in the Industry; and he referred to a method which was readily available to all those in gas-works—the inert gases from the chimney stacks. During the last three years the South Metropolitan Company has used the waste gases from the retort settings and conducted them by a pipe system to most parts of the works. In this way holders as large as 6 million and 12 million cu.ft. have been successfully purged.

Mr. H. D. Madden urged that rules should be formulated for the examination of structures and buildings generally, and Mr. G. C. Pearson asked that the recommendations in the report should be adopted in their entirety. He also suggested that the circumstances of mishaps should be made known to the Committee; while salient points emerging from such accounts should be embodied in the recommendations and voluntary rules, the source of such information would be considered confidential. Both Mr. L. Hartley and Mr. C. M. Croft spoke of trouble caused by grit getting into the cups of holders, and Mr. R. N. Webb outlined the safety practice of the Leeds Gas Department.

Furnace Atmospheres.

THE last item on the programme for Tuesday morning was presentation and discussion of the Institution Gas Fellowship Report. This gave the results of a continuation of the experiments described in the Fellowship Report for 1935-36 and dealt with the influence of furnace atmospheres on the scaling of mild steels at temperatures from 1,200° to 1,400° C. Mr. Alan Taylor has held the Fellowship since Nov. 9, 1936. The Report gave a detailed description of the apparatus and technique employed, which, while similar to that described in the earlier report, had to be modified to overcome difficulties inherent in the higher temperatures concerned. The main conclusions to be derived from the experiments are that the rate of scale production is greatly increased by the use of high temperatures as compared with the effects of free oxygen and sulphur dioxide; that sulphur dioxide has a very deleterious effect, although this is not so important at higher temperatures, and above 1,300° C. 4% oxygen has a more harmful effect than 0·2% sulphur dioxide; and that carbon monoxide used at the rate of 4% has comparatively little effect on reducing scale formation. As the liquefying temperature was approached there was a very rapid increase in scale formation, but when once the scale had formed there was only a slow rate of increase with increase of temperature.

The report was introduced by Professor Cobb and by Mr. Taylor. In the few minutes' discussion which ensued Mr. Clark Jackson expressed his gratification that Institution research is now embracing the industrial field of the Gas Industry's work and his hope that research in this direction will be extended.

Gasification.

ON Tuesday afternoon there were two reports—the 43rd Report of the Joint Research Committee on the investigation of the use of oxygen and high pressure in gasification, and a communication by Dr. J. G. King on complete gasification of coal and methane synthesis. The first report was presented by Mr. H. C. Smith and introduced by Professor Cobb and Dr. F. J. Dent. It dealt with the continuation of the investigations of the synthesis of gaseous hydrocarbons at high pressure. It has been found that a considerably extended range of gasification is obtained by hydrogenation up to 900° C. both with coals subjected to preliminary carbonization up to 500° C. and with coals not subjected to preliminary heat treatment, yields of 500 to 600 therms per ton of gaseous hydrocarbons having been obtained. Of the carbon of the coals 70 to 85% was gasified, the rate of hydrocarbon production being well maintained towards the end of the experiments when only small amounts of residue remained.

Similar results were obtained with high-temperature cokes—*i.e.*, those which had previously been subjected to a temperature of 800° C. The yield of hydrocarbons from such cokes below 800° C. was low, but 370% increase in yield was obtained by further hydrogeneration up to 900° C. No fewer than 520 therms of gaseous hydrocarbons per ton were obtained with a gasification of 83% of the coke.

In some of the experiments on coke the production of methane reached equilibrium in the gas produced, which with pure hydrogen consisted only of methane and hydrogen. The report gave the calorific value of the gas at equilibrium at different temperatures and pressures.

Experiments were described on the effect on gasification of the addition of alkalis. Such addition not only greatly accelerates the rate of gasification at relatively low tempera-

tures, but also increases the ability of coke to withstand heat treatment without losing its reactivity towards hydrogen, and considerably reduces the caking properties of coals.

Another series of experiments on hydrogenation of coals with varying rates of hydrogen supply showed that during the initial period of hydrogenation, when the coal was being raised in temperature, hydrocarbons were produced equivalent to 415 therms of 500 B.Th.U. gas per ton per hour. Direct comparisons cannot be made with the 7 therms per hour produced in normal commercial operations, but the difference, the report points out, is so wide as to be of real significance.

An Impressive Feature.

PROFESSOR TOWNEND, who opened the discussion, suggested that the most impressive feature of the work is the remarkable rate of gasification which the experiments indicate as quite normal to this method of working; and the outstanding future problems would seem to be of a mechanical type, in regard to such matters as throughput, and coking properties of the coals concerned. Taking a broad view, he said, from a national standpoint it would seem desirable that both carbonization and gasification methods of gas production should always be complementary, and among other things the new gasification process, if successfully developed, should give greater control of the coke market. Dr. J. G. King discussed the question of control of the heat of reaction of the hydrogenation process when the experiments are continued on a larger scale, while Mr. J. E. Davis gave some of the results obtained in the Central Laboratory of the South Metropolitan Gas Company with a reaction tube 4 in. in diameter. "The experiments," he said, "have revealed several facts of considerable potential importance. We can obtain substantially complete conversion to methane under widely varying conditions of raw material, temperature, and pressure. If we are prepared to be reasonable and to limit our demands for methane to such as will suffice for the production of a gas having a calorific value of 500 B.Th.U. per cu.ft. we can obtain this quantity of methane at a rate substantially in excess of that shown by any existing gas producing process operating in a vessel of the same size.

"Quite surprisingly the use of a coking coal does not appear to give rise to the troubles that we had expected. The yield of tar can be controlled by choice of the conditions within wide limits. A high proportion of the nitrogen in coal is converted to ammonia, and this should be obtainable at a concentration in the liquor which would make its recovery quite a different commercial proposition from the treatment of ordinary gas liquor. The difficulties which are due to the presence in ordinary coal gas of hydrogen cyanide and naphthalene simply do not arise. Sulphur behaves in a most interesting manner. At the South Metropolitan Gas Company we have found that an unusually high proportion of the sulphur in the coal is eliminated in the gas, leaving a coke of particularly low sulphur content. Incidentally, this coke displays exceptionally high reactivity and adsorptive properties. Of most significance is the fact that substantially all of the sulphur in the gas is present in the form of hydrogen sulphide, and after removal of this impurity there remains considerably less than 1 gr. of organic sulphur compounds per 100 cu.ft. of gas."

A Progress Report.

THE Communication presented by Dr. King was a progress report of experiments at the Fuel Research Station on the complete gasification of coal in a modified water gas plant, and it is shown that sized carbonaceous coals may be successfully gasified, a yield of 205 therms per ton being obtained. While coals of medium volatile matter are too highly caking to be treated by these methods, the experiments have shown that coals having a high volatile matter can be treated. The yield in therms per ton is about 18% lower than that obtained from carbonaceous coals. A further series of experiments has been concerned with the use of catalysts for the synthesis of methane from hydrogen and carbon monoxide for the purpose of enriching low grade gas in a two-stage system of complete gasification. The molybdenum catalysts were unsatisfactory, but experiments with a cobalt-thorium catalyst have given encouraging results. A description was also given in the report of experiments which have been carried out with the Fuel Research Station Vortex burner on the complete gasification of coal with oxygen and steam at atmospheric pressure.

A Comparison.

EXPERIENCE at the Imperial College of Science and Technology in the use of catalysts in the production of methane from hydrogen and carbon monoxide was touched upon by the first speaker in the discussion on the report, Professor Newitt, who expressed the view that there are not insuperable difficulties in obtaining a catalyst rugged enough for practical use with a gas containing sulphur. A highly interesting contribution was made by Dr. F. J. Dent, who compared the possibilities of producing hydrocarbons by hydrogenation, as in the work at Leeds, with those of producing hydrocarbons by interaction of carbon monoxide and hydrogen. The hydrogenation process, he observed, can be arranged so as to leave a non-caking residue which should be ideal for a rapid gasification in steam, whereas, when enriching by interaction of carbon monoxide and hydrogen, the coal must be gasified in steam directly or subjected to some special treatment to prevent caking. The hydrogenation process is independent of catalysts with their attendant sources of trouble, but, with the progress that is being made, we can take it as most probable that those troubles will eventually be overcome. When that is achieved, it appears to Dr. Dent that the carbon monoxide hydrogen process will be more flexible than hydrogenation in enabling the product to be readily varied from gaseous to liquid hydrocarbons when the demand for gas is low. As now pictured, a hydrogenation process for the production of gaseous hydrocarbons is vastly different from the hydrogenation process for the production of liquid hydrocarbons and it seems that if a works were laid out to produce relatively widely varying amounts of both gaseous and liquid hydrocarbons by hydrogenation, it would always have a considerable part of its plant lying idle, and so defeat the aim of utilizing off-peak load facilities. On the other hand, when synthesizing hydrocarbons from carbon monoxide and hydrogen, variation from a gaseous to a liquid product will mainly be a matter of regulating the temperature of the catalyst chamber with little requirement for additional plant. Only thorough investigation will tell us which of the processes, or a combination of the two, will be most usefully applicable to the Gas Industry.

Refractory Materials.

THE first Communication to be received and discussed on Wednesday morning was the Report of the Refractory Materials Joint Committee. Prior to its presentation by Mr. W. Grogono and its introduction by Mr. A. T. Green, Mr. Dixon referred to the death of Dr. J. W. Mellor, which took place just prior to the Institution meeting last June, and associated the feelings of those present with the Committee's recognition of the loss sustained by Dr. Mellor's death. Presenting the Report, Mr. Grogono explained that a suggestion had been put forward by the Committee to the Council of the Institution that a Mellor Memorial Lecture should be held and that this Lecture should be run on the same lines as the William Young Memorial Lecture. This suggestion has been favourably received, and the Institution is now in communication with other bodies with whom Dr. Mellor was connected. After a gracious tribute to Dr. Mellor, Mr. Green introduced the report in his usual breezy style and met with the usual hearty reception.

The report included descriptions of the following investigations: The action of alkalis on refractory materials; the effect of hydrocarbon gases; the action of slags; the refractoriness under load test; the behaviour of sillimanite mixes on being pressed; the measurement of apparent porosity; jointing cements; and an examination of samples of silica brickwork, taken from a vertical retort, showing evidence of pronounced alkali attack.

Further work has been carried out on the effect of alkali chlorides on refractories and it is shown that degeneration of

refractory properties is caused by the migration of small amounts of constituent oxides to the surface where they become completely volatilized. But whereas migration is favoured with sodium chloride in dry air, it is considerably reduced when the reaction with sodium chloride occurs in the presence of steam.

The investigations on the action of methane have been continued, and it is shown that when the iron spots are brought to a reactive condition, methane decomposes into carbon dioxide and hydrogen. The increasing deposit of carbon round the iron spots causes disruption of the brick. The preliminary investigations on the action of slag have been continued, and the corrosive action of lime itself has been studied.

A third variant of the refractoriness under load test, the maintained temperature—increasing load method, has been applied to silica bricks. Although the results show a good deal of variation, average values can be used to discriminate the different brands. Silica bricks are unable to bear a load of 50 lb. per sq.in. for long periods at temperatures more than 50° C. below the failure point in the normal method.

The difficulties obtaining in determining the apparent porosity of refractory materials are well known, and an attempt has been made to evaluate the different methods. Nineteen materials were tested by several methods and the inherent and random methods associated therewith are discussed. The work on jointing cements has continued, 22 commercial cements having been examined for refractoriness and other properties. A new test to evaluate workability has also been devised. While it may be said that the cements are reasonably workable, some of them seem inferior in mechanical stability at high temperatures to the brick with which they are intended to be used.

Lack of time limited discussion on the report, and there were only two speakers. Mr. T. F. E. Rhead commented on jointing cements, which he likened to patent medicines of the retort house. There was, he said, a plethora of those recipes, and, while some were good and compounded on sound lines, there were many which were worthless, even dangerous, and, moreover, they varied in composition and grading from consignment to consignment. The case of spraying cements was even worse. He was glad that the B.R.R.A. was pursuing the subject, which was a vital one to the Industry, and it was to be hoped that some rough specifications would be forthcoming to keep out the charlatan. Dr. A. L. Roberts, of Leeds University, spoke of the great value of Mr. Green's work to himself and his co-workers at Leeds.

Hot Patching of Retorts.

THEN Mr. T. F. E. Rhead introduced the Paper on Hot Patching of Retorts, prepared jointly with Mr. S. K. Hawthorn and Mr. V. H. Deacon. This Communication dealt with the problem of the successful repair of retorts while hot, the solution of which has long been sought. Following the work of the British Refractories Research Association (published in the 23rd and 24th Reports of the Refractory Materials Joint Committee) on the use of dry mixtures for patching, large-scale trials were carried out at the Works of the Birmingham Corporation Gas Department. The Paper described the result of the evolution of a successful method of repairing leaks in continuous vertical retorts by hot patching using dry materials and an oxy-coal gas flame. Details were given of the cements and fluxes used and of the apparatus and technique adopted, together with the devices used for feeding the dry materials into the flame. It is shown that the cost of repairs has been reduced by one-half, and the period between cold repairs greatly extended.

A Proved Process.

IN the course of the discussion Mr. G. C. Pearson remarked that with the introduction of upwardly heated vertical retorts the effects of leakage had become more serious than with the downwardly heated type. The zone of greatest heat was now at the bottom of the retort, and leaks in this vicinity were not protected by the formation of scale. Spalling of the silica in downwardly heated retorts was the determining factor influencing the life of the plant before the first cold repair. The great reduction in spalling that had accompanied the change in the method of heating, however, should enable them to obtain a life of an extra year or so with the upwardly heated type. The latter unfortunately were liable to become rapidly uneconomical for work owing to extensive leakage. However, with the repair system described a range of upwardly heated retorts put to work in 1937 had been so conserved that no leaks of any serious dimension had been allowed to develop. Dr. E. W. Smith paid a high tribute to the Authors' work and congratulated them on its successful outcome. The stage had been reached for the adoption of hot patching on a number of works to allow of the accumulation of information. At the same time, he suggested that it had never been shown that when properly applied from the beginning wet spraying had caused any trouble. Mr. M. S. Gaskill, of West's Gas Improvement Company, Ltd., outlined a few points from his firm's work which to a great extent confirmed the results obtained at Birmingham; and Mr. G. E. Currier remarked that, as the life of a retort setting was reduced by 100 to 200 days by each cold shut down, by the use of the hot patching process the period between shut downs would be extended and the life of the retorts increased.

Production of Free Burning Coke.

THE next item was the presentation of the Paper on the production of free-burning coke in continuous vertical retorts by Mr. James Jamieson and Dr. J. G. King. This dealt with experiments which, as the result of further collaboration between the Fuel Research Station and Edinburgh Corporation Gas Department, have been conducted on a set of four vertical retorts at Granton Gas-Works. These retorts were part of a larger bed, but were equipped with their own collecting system and facilities for measuring and sampling. Five coals having a carbon content of about 82%, drawn from four Scottish coal-fields, were selected for test. The normal temperature of carbonization was reduced to 700° C., and although this reduced the make per ton to 52 to 60 therms, a richer gas was obtained. The lump coke was tested empirically for combustibility. It was found to burn almost as well as a standard low-temperature coke. The average yield of coke per ton of coal carbonized was 12·1 cwt., of which 10·5 cwt. were suitable for sale as lump smokeless fuel for use with open grates.

Introducing the Paper, Mr. Jamieson said that it had been shown that an increase at Edinburgh from 28s. 6d. per ton for normal coke to 36s. per ton for smokeless fuel would approximately allow of the production of gas at the same price per therm. The actual reduction in gas yield is of the order of 16-24 therms per ton of coal. The economic success of the process visualized by these experiments, he added, would depend, however, upon the price realizable for the smokeless fuel. If a reasonable increase of price were obtainable, there is no reason why the Gas Industry should not apply this technique where suitable coals are available and contribute still further as a solid fuel industry in the campaign against the production of smoke.

Who Shall Supply the Fuel?

MR. F. B. RICHARDS, who opened the discussion, said that if there is proved to be a market for an easily ignitable, free-burning, smokeless fuel, why should the Gas Industry not be the suppliers of that fuel instead of standing by while a new branch of the carbonization industry came into being? The Authors had shown that the Gas Industry had the means within its power of supplying the need, and the novelty of their contribution lay in the fact that to supply the special fuel it was not necessary to spend money to build a plant solely for the purpose. As for the selection of coal, this was one further example of the great value of the Fuel Research coal survey. By the methods discussed in the Paper the increased cost of producing a satisfactory product might well be less than that of smokeless fuel made in plants specially built for the purpose, with no convenient outlet for gas, involving the establishment of a new organization for production and sales. Experience at Liverpool of the manufacture of "Dryco" was outlined by

Mr. E. Astbury, who mentioned that sales had increased from 3,000 tons per annum in 1931 to 17,000 tons in 1937. As the sales of "Dryco" increased—in most cases it had replaced coal in the domestic grate—there had been a decrease in the tonnage of coke exported. In 1931 his export had been 17,000 tons; in 1937 and 1938 there had been no surplus coke available for export. He supported the Authors' conclusion that the Gas Industry could produce a satisfactory smokeless domestic fuel for use in ordinary well grates with advantage to the undertaking and benefit to the community.

Attention was called by Mr. R. W. Hunter to the Authors' indication that they did not consider fuel for special coke grates, since those grates already provided a solution to the problem of smoke reduction. It might well be, he said, that those grates also provided a solution to the problem of finding a permanent remunerative market for coke and that they would also lead to an increase in gas sales. In London they had proved very popular without any special sales campaign, and he thought that attention should be kept carefully focused upon them, pending the production on a large scale of any new type of fuel. Mr. W. L. Boon remarked that it was very largely due to the London and Counties Coke Association that the special grate for burning gas coke had been popularized in this country. There were about 250,000 of those grates in the London area, and that figure was a very large proportion of the total number of grates in the country. In the Association's area, however, there must be something like 2,000,000 coal-burning grates, and from the point of view of spreading the use of coke the experimental work which was being carried out at Edinburgh was to be welcomed.

Solid Fuels in Open Grates.

THEN Dr. Harold Hartley introduced the Paper by himself and Dr. W. Davidson on results attained with solid fuels used in open grates for heating living rooms. This described experiments on the combustion of various solid fuels in open grates, the type of grate used being most suitable for the particular type of fuel. Although bituminous coal is still, in spite of its other drawbacks, the most popular fuel for heating domestic living rooms, some 25 to 30 million tons being used annually, the highest radiant energy was obtained with gas-works coke. This fuel also proved to be the most economical in use, the cost per therm in London being 1·85d. as against ordinary bituminous coals, the fuel most widely used, the cost of which in London is 2·0d. to 2·3d. per therm. These costs are for thermal value only, and do not take into account other costs incurred with the use of bituminous coals—namely, chimney sweeping and other cleaning costs due to the smoke produced in their combustion. The efficiency of both coals and cokes was found to be unaffected by the rate of burning provided the grate is kept full. It is interesting to find that the radiant efficiency of the coke grates used was uninfluenced by the chimney pull.

In the course of his introductory remarks, Dr. Hartley mentioned that in addition to the convenience and ease of kindling by means of the gas burner, a further advantage which results from the burning of coke in a properly designed coke grate is that the rate of burning, and, therefore, emission of heat, can be regulated relatively easily. He emphasized that the Authors' experience with a number of vertical retort cokes had been very satisfactory, and if the Gas Industry so desire, it can make available for the public a good coke of uniform quality. If it does this, a very considerable demand will be experienced.

Co-ordination Necessary.

"LOOK to the present" was the keynote of the remarks of Dr. E. W. Smith, who opened the discussion. Dr. Smith deprecated the fact that so many people who were interested in the development of the Gas Industry should leave so much of the development of the technique of coke to the London and Counties Coke Association. He felt that there was some justification to-day for the Institution itself to co-ordinate all the work which was going on in the development of coke and its properties in the country as a whole. He urged that the Industry and the Institution should take the question of coke seriously. It was, he contended, no use looking forward to a time when, as he hoped, there would be an all-gas industry if in order to make it so they neglected something for a period which brought quicker the all-gas era. His feeling was that in spite of the wish to have an all-gas industry, it was desirable to work up to the limit the value of the solid material, because there was still a long way to go before the all-gas method could be compared on a cost basis with the present methods of gas production. Gas coke, roundly asserted Mr. H. J. Hodsman, who has carried out so many investigations on its properties and use, is the most efficient solid fuel for open fires, once the consumer has equipped himself to take advantage of its high radiation factor.

Mr. John Roberts was in critical mood. The Authors' comparison of the various fuels, he argued, was invalidated by the fact that the best conditions had been taken for gas coke and adverse conditions for other fuels—particularly Welsh coals of the "smokeless" type. In the case of anthracite and steam coals, he said, the Authors did not use the correct size of coal, nor did they use the correct weight of charge in any case. Mr. Roberts elaborated his contention with a series of lantern slides giving graphs of the radiation efficiencies of Welsh coals as determined by a new radiometer he has designed. Mr. W. L. Boon came forward to champion the cause of gas coke. He said the economic situation in the Gas Industry demanded that the value of coke should be enhanced. The proper perspective in its relation to future gas developments should not be lost. Coke would be available for very many years, and the Industry would make a grave mistake if it neglected its development or relaxed its efforts at this time on any promise which the future might hold for gas.

Pipes.

THREE reports were submitted in the final session on Wednesday afternoon—those of the Pipes Committee, of the Sub-Committee on Unaccounted-for Gas, and of the Gas Education Committee. The first report, which was presented by Mr. H. J. Escreet, contained a revised list of approved makers of wrought iron, gas, water, and steam tube strip; a specification for wrought iron bars for gas-carrying tubulars and fittings; a list of approved makers of wrought iron bars for this class; and a specification for wrought iron gas, water, and steam qualities tubes and fittings. In addition it included recommendations dealing with fusion between electricity and gas services, and a method of extinguishing fires in gas mains.

There was not a great deal of discussion on the report, and it was for the most part concerned with points of detail. Mr. Dean Chandler, in a Communication read by Mr. A. S. Lee, observed that there appears to be some suggestion that to-day the conditions of gas supply are so changed that the substitution of steel for wrought iron can now be justified. "This possibly may be sound for gas undertakings supplying 'dry gas,'" he continued, "but to agree that the substitution of steel for wrought iron is justified without reference to the circumstances and the conditions of gas supply which exist is, I think, unwise and may have very unfortunate results. There must still be many undertakings in the country that have not yet adopted gas dehydration, and experience has shown that for moist gas wrought iron is the more suitable material, for two reasons. Firstly, the actual amount of corrosion is less with wrought iron, and, secondly, the wrought iron corrosion products are in the main of much coarser size and therefore less liable to be carried forward by the gas stream to be deposited at points where there is a considerable change of direction or section of the pipe and to those points where the gas issues through the orifices of gas-consuming appliances." Mr. Dixon related his experience of the corrosion of wrought iron services at the outside radius of bends, and Mr. Escreet suggested that the best method of combating this corrosion is to employ complete troughing.

Unaccounted-for Gas.

THE interim report of the Sub-Committee on Unaccounted-for Gas was introduced by Dr. H. Hollings. It contained a recommended method of calculation of gas quantities, together with a discussion of factors influencing gas unaccounted-for and of the influence of the

gas drying process upon gas quantities. The report also included appendices dealing with the computation of gas volumes by means of tabular numbers (including factors to be corrected for), a typical calculation of gas unaccounted-for, and a description of a meter-proving apparatus.

Mr. B. R. Parkinson, in the discussion, characterized the report as a curious blend of the extremely elementary and the highbrow; and, he said, "accuracy is all very well, but it may run to seed. Too much accuracy is out of place in the computation of that which in itself constitutes an inaccuracy." Mr. E. M. Edwards explained how since 1931 at Port Talbot systematic work has resulted in a reduction in unaccounted-for gas from 10·6% to 5%. He mentioned that during the first survey of meter testing, 7% of the meters were registering against the undertaking, and even to-day 5% of the meters are so registering; and he expressed the opinion that too much is expected of the present type of meter valve. Mr. J. H. Bingham came forward in defence of the oft-timed much-maligned meter. What he considers to be a major influence on the determination of gas consumed is the overloading of meters beyond the capacity for which they are designed. "If," he remarked, "a meter will not register a pilot consumption, its inability to do so can be observed; but the failures to register correctly at overloads cannot be seen in service, and the losses due to this ill-treatment may be much the greater."

Education.

THIS brought us to the final report to be considered—that of the Education Committee. This recorded the important change which has been made in the regulations as regards the eligibility of candidates to sit for the Higher Grade Examinations of the Institution. Up to this year candidates before being eligible to sit for the examinations had to be engaged on the practical side of the Industry. These regulations were found to be difficult to administer in practice. The Council, on the recommendation of the Committee decided to modify the regulations so that from and including the 1939 examinations candidates for the Higher Grade Examinations in Gas Engineering (Manufacture) or (Supply) will not be required to be engaged on the practical side of the Industry. Attention is drawn in the report to the large number of candidates for the Diploma in Gas Engineering (Manufacture) and mention is made of the fact that major courses have been approved for four new centres, and that two centres have been added to those having approved minor courses and eight to those having approved courses in gas fitting.

During the discussion on the report, in which quite a number took part, Mr. H. C. Creasey pleaded, not for the first time, for an exploration of the possibilities of giving wider facilities to students to attend long or short classes for day or whole-time instruction—a matter which, he thinks, will have to be faced sooner or later. Dr. P. C. L. Thorne also emphasized the importance of part-time day instruction. There are, he remarked, many difficulties, geographical and otherwise, which face the student in attending classes after working hours, and the solution of that problem is to allow them to attend classes during working hours, either by releasing them early from work or, better still, releasing them for half a day or a whole day, so that they can give their minds to the subjects they are attempting to study. Dr. Thorne also mentioned that, in connexion with short courses for teachers, it was hoped to introduce in Birmingham next year a more advanced section dealing with gas supply. Mr. A. E. Ruffhead expressed his gratification that the Institution Council is investigating the question of adequate salaries for the staffs of gas undertakings, for he feels that this is bound up to a certain extent with the success of the Education Scheme. "If," he said, "we want the best men and if we are going to train them, we must pay them adequate salaries." Dr. J. N. Long congratulated the Education Committee on the repealing of a "stupid, unworkable regulation"—the regulation concerning engagement on the practical side of the Industry. He also asked that if a fitter has a higher City and Guilds certificate in gas fitting he should automatically be exempted from the first year of the Gas Engineering (Supply) Course. Mr. James Mitchell explained how at Leicester the plan had been adopted of a "miniature Watson House" with a full-time instructor, and expressed the opinion that other undertakings would benefit if they instituted a similar scheme.

Presentation of Diplomas & Medals.

MR. DIXON then presented Diplomas to the following: Diplomas in Gas Engineering (Manufacture), 1938, to E. C. Anderson (Wirral), 2nd Class; E. Bates (Stalybridge), 1st Class; S. C. Bentley (Leicester), 2nd Class; N. Calvert (London), 1st Class; V. H. Deacon (Birmingham), 2nd Class; J. S. Fox-Andrews (Bristol), 2nd Class; L. F. Garner (Hitchin), 1st Class; W. M. Gledhill (Worcester), 2nd Class; C. W. Hemingway (Shipley), 1st Class; A. S. Horner (Wallasey), 2nd Class; J. Malsbury, B.Sc. (Hertford), 1st Class; A. A. Mitchell (Dunfermline), 2nd Class; V. J. J. Siddons (Sheffield), 2nd Class; J. A. Tomes (Walsall), 1st Class; A. V. Wainwright (Shrewsbury), 2nd Class; and G. G. Warne (Portsmouth), 2nd Class.

A Diploma in Gas Engineering (Supply) for 1938 was presented to J. B. Walsh (Stockport), 1st Class.

The Chairman said they then came to the presentation of the Charles Hunt Memorial Medals. The Medals were awarded to the candidates who were placed highest in the examination for the diploma in either gas engineering (manufacture) or gas engineering (supply), and who had attained a standard sufficient to justify the award of the Medals. The Medals were presented in memory of one of the pioneers of their Industry, a man who did very much for the Institution, and they were happy indeed to have with them that day a member of the family of the late Mr. Charles Hunt. He had attended in order that he might show his sympathy and offer his congratulations to those to whom the Medals were awarded, as well as to show his interest in the Institution Education Scheme.

Mr. Hunt then presented the Medals to Mr. J. Malsbury and Mr. J. B. Walsh.

Mr. Dixon reported the election to the Institution of 6 members, 35 associate members, and 1 associate. Their names will be found elsewhere in our issue to-day.

Concluding Proceedings.

MR. W. CLARK JACKSON proposed, and Mr. J. Hunter Rioch seconded, an omnibus vote of thanks to all who had helped to make the meeting a success, and response was made by Mr. Dixon and by Dr. Braunholtz, who said it would be his main concern to see that the organization and staging of the autumn research meetings keep pace with the growing requirements.

The Institution Research Luncheon - -

A large number of eminent scientists, engineers, representatives of Government Departments and of scientific and technical societies, and executives of the Gas Industry, accepted the invitation to luncheon extended by the President, on whose behalf Mr. George Dixon presided.

Mr. HAROLD C. SMITH (Immediate Past-President), proposing "The Guests," first expressed sympathy with the President in his illness. Continuing, he said that while the members of the Institution were delighted to welcome all their guests, he would be bare-faced enough to say—in spite of the presence of the Chairman of the Anti-Bribery and Corruption League—that they had invited the guests because they wanted something from them. The function was not just an ordinary customers' luncheon. The Institution wanted something more valuable than orders; it wanted help.

In the first place, he welcomed Professor John W. Cobb, who had just retired from the Livesey Professorship at Leeds, and his successor, Professor D. T. A. Townend. He asked that Professor Cobb would continue to give the Institution in his retirement all the help and advice that he possibly could give. All they could ask of Professor Townend was that he would do for the Institution what Professor Cobb had done in the past.

There were many categories of guests. Of the research chemists who worked for the Institution they asked for the continuance of their loyal service and of their patient and methodical investigation of the many problems they were asked from time to time to solve. Of the members of the various Committees of the Institution he asked for the continuance of their very necessary duties, often very humdrum, but occasionally entertaining when they forgot that they had a serious job of work to do and constituted themselves temporarily into debating societies. Of Sir David Milne-Watson and other Chairmen of gas undertakings the Institution asked for the continuance of their encouragement and support—both financial and otherwise—without which its work would be impossible.

There were present the representatives of kindred institutions and organizations whose work was often closely associated with that of The Institution of Gas Engineers. The Institution also welcomed representatives of various Departments of His Majesty's Government. Perhaps it would be least embarrassing both to them and to the Institution if he left to their imagination the nature of its several requests; he felt sure they had a fairly good idea of what they could do.

For the first time the Institution was honoured by the presence of Sir William Bragg at one of its functions [Applause], and there was no one who would be more welcome than the President of the Royal Society at any function of an organization which was doing scientific work. The request which the Institution would make to him was that the occasion would not be the last on which he would honour them.

Coupling with the toast the name of Sir Alfred Faulkner, Mr. Smith said that Sir Alfred, in addition to holding the office of Under-Secretary for Mines, was a member of the Fuel Research Board, with which Board the Institution was more closely associated to-day than it had ever been. He represented a Ministry which was concerned solely to look after one industry, and he was one of those representatives of the Government whom the Institution asked for help.

High Technical Qualifications.

Sir ALFRED FAULKNER, C.B., C.B.E. (Under-Secretary for Mines), responding, said that, having looked through the list of objects of the Institution, he had been very glad indeed to note that education and research occupied so very prominent a place among them. It was an excellent thing that the Institution had set so high a degree of technical qualification for those who were to be Members or Associate Members; there was nothing which did more to maintain and to raise the status of a profession than that there should be high technical qualifications for membership of its governing body.

It was stated in the 4th Report of the Research Executive Committee, 1937-38, that from time to time the Gas Industry had been criticized for the apparently small sum of money it expended on centralized research. It was often alleged also, continued Sir Alfred, that the coal industry as a whole and the users of coal did not devote to research anything like so much money as was devoted to it by the oil industry, for instance. But he was not at all sure that that was right. He believed that if one could really add up all that was done by the Government, by the learned societies connected with coal in all its forms, by individual collieries, by the combustion appliance manufacturers, by coke-oven research associations, by The Institution of Gas Engineers, and by individuals in the industries connected with coal, it would be found that the total amount of money spent in research on the use of coal was a staggering figure.

Success to the Institution.

Sir WILLIAM BRAGG, O.M., K.B.E., F.R.S. (President of the Royal Society), proposing "The Institution of Gas Engineers," said how very much he admired its work and how very much he wished it success. Sir William recalled that some 70 years ago the engineers in the Industry began to gather together for mutual help and protection, as a body engaged in a busy industry. Later they came to consider education as being within their province, and had founded a system of education and a system of qualification for membership which were indicative of very clear thinking. Later they began to enquire into research and had carried on research at Leeds and elsewhere—and in that connexion he said how sorry he was that his old friend, Professor Cobb, was retiring from the work he had been doing. The Institution was carrying on very important technical researches, and it was very interesting that it should be doing that in connexion with bodies such as the Leeds University, the British Iron and Steel Federation, the Society of British Gas Industries, and the Department of Scientific and Industrial Research, which he felt sure would be even more closely in alliance with the Institution in future than it is to-day.

The subjects of the researches were very interesting, and the Institution was making great efforts to carry on the work satisfactorily. It was trying to correlate all that work and to draw together all the various sources of research. A very large amount of work was distributed in various parts of the country, and it was important so to direct all that work that the various parts should reinforce each other as far as possible. A certain amount of overlapping was good, but still it was advisable to have the whole circuit of researches carried out more or less under one general policy.

The gradual development of the Institution was quite normal and right, and the last and finest step of all was to take to research, because they had learned that in the world and in Nature there was a vast amount to be discovered which could be of benefit to the Industry. They must look for it, because if they wanted to catch a fish, they must go fishing! It was certain that they must work for efficiency with all their might, in order that they might stand up against countries in which orders could be given more quickly and were more readily obeyed. The nation itself was something like the Gas Industry, and had to go through the same process of development. That process was going on and many of those present would live to see it developed far beyond the present stage. It became necessary to take stock of the nation and to see what they were all able to do, and he supposed that the Government would be taking that in hand presently. It would be assisted in that task by the presence of bodies such as The Institution of Gas Engineers, in which were assembled all those who possessed most valuable knowledge on particular subjects. When the Officers of State came to find out what each part of the nation could do, they had but to come to such an Institution and to find that already it had in its hands a list of men capable of doing good work for the country and only too ready to do it.

The CHAIRMAN, responding to the toast, said that they were a proud Industry, because they believed they were charged with a mission to carry on research, to enable them to utilize the national coal resources so as to give the best possible service to the consumers and to the country as a whole. Both Sir William Bragg and Sir Alfred Faulkner had referred kindly to that research work and had mentioned education particularly, and the Institution regarded education as being by no means the least of its research subjects. It had done a great deal towards educating the younger men in order that they should be fit to tackle the problems with which they would be faced a year or two hence. He had heard it said quite recently that possibly rather too much had been done and rather too much money had been spent on education. The members of the Institution, however, did not feel that the money spent on and the care devoted to education was likely to be abused.

Commenting upon the statement one often heard that the Gas Industry rendered a great service during the Great War, the Chairman said that research and practice had carried the Industry a long way forward since those days. It was not satisfied to live on the glory of the memory of the service it performed some 20 years ago; it must be prepared, and indeed it was prepared, to pool resources and interests to meet the social, economic, and industrial needs of the country either in time of peace or of national emergency. So the call to-day was for research and even more research, and the members of the Institution were indeed pleased to welcome to the luncheon so many gentlemen representing all branches of science connected with the coal carbonizing and kindred industries. They had come to realize that there was no such person as the complete gas engineer. The Industry demanded the co-operation of engineers, chemists, physicists, metallurgists, and those engaged in many other branches of endeavour. The secret was that all concerned with the Institution's research were pulling together, and therein lay their strength.

Mr. E. V. EVANS, O.B.E. (Chairman, Research Executive Committee), proposed a toast to the Chairman. It would be most ungracious, he said, to allow the gathering to disperse without giving an opportunity to express appreciation and gratitude to Mr. Dixon. It would be appreciated by all who knew Mr. Robertson, the President of the Institution, and who knew the seriousness with which he regarded any duty that was placed upon him, that he must be very much saddened by his enforced absence. Yet he must be comforted by the fact that his Vice-President had taken charge of the meeting and had carried through the proceedings admirably. Mr. Dixon was a man who had gradually climbed to eminence in the Industry, and he was about to occupy the coveted position of the Presidency of the Institution. That he would occupy the position with efficiency and dignity he had already proved.

The CHAIRMAN, responding, said he could not refrain from expressing his great regret that Mr. Robertson was unable to attend and preside, and to reply to so personal a toast.

New Members of the Institution

The following were elected to the various classes of Membership of The Institution of Gas Engineers on Wednesday, Nov. 2:

Membership.

Beale, Seymour John Fleming, General Manager and Director, The West Gas Improvement Company of America, Incorporated, New York.
Chaplin, Stanley Edward, Civil Engineering Assistant, South Metropolitan Gas Company.
Davenport, Thomas Alfred, Gas Engineer, West's Gas Improvement Co., Ltd., Manchester.
Edmondson, Francis Charles, General Manager, City of Perth Electricity and Gas Department, Western Australia.
Hartley, Harold, D.Sc., Head of Research Department, Radiation Ltd., Birmingham.
Walker, Leslie John Lindsay, B.Sc., Director and General Manager, R. & J. Dempster, Ltd., Manchester.

Associate Membership.

Bairstow, Robert, Pupil Engineer, The Gas Light and Coke Company.
Barrington, Albert Henry, Senior Technical Assistant, Burton-upon-Trent Corporation Gas Department.
Baxendale, John de Voisey, Technical Assistant, Bingley Urban District Council Gas Department.
Bennett, Alec Raymond, M.Sc., Research Physicist, Radiation Ltd., Birmingham.
Brinsley, Frank, M.Sc.Tech., Technical Service Manager, John Wright & Co., Ltd., London.
Christie, John Wishart, Assistant Gas Engineer, Burntisland Corporation Gas Department.
Coates, Harold Radcliffe, Draughtsman and Relief Shift Engineer, Oldham Corporation Gas Department.
Davidson, William, B.Sc., Ph.D., Chemist, Radiation Ltd., Birmingham.
Fitzpatrick, Thomas, B.Sc., Chief Chemist, Worcester New Gas Light Company.
Gaunt, James Greenwood, Assistant Engineer, Calverley and Horsforth District Gas Company.
Jackson, Albert, M.Sc.Tech., A.I.C., Research Assistant, West's Gas Improvement Co., Ltd., Manchester.
Johnson, Benjamin William, Chief Chemist and Technical Assistant, St. Helens Corporation Gas Department.
Junkison, Norman Rex, Staff Officer, The Gas Light and Coke Company.
Kettlewell, Harry, Shift Engineer, Oldham Corporation Gas Department.
Lake, Frank, B.Sc., Research Chemist, Radiation Ltd., Birmingham.
Lister, Horace Killingbeck, Engineer, Manager and Secretary, Holmfirth Gas Light Company.
Litler, Fred, B.Sc.Tech., Engineering Assistant, Keighley Corporation Gas Department.
Longhurst, Reginald Stanley, Assistant Chemist, Rochdale Corporation Gas Department.
Lord, John Kenneth, Technical Assistant, United Kingdom Gas Corporation, Ltd., Manchester.
Mitchell, Andrew Adie, Technical Assistant, Dunfermline Corporation Gas Department.
Munslow, Kenneth John, Junior Technical Assistant, Cradley Heath Gas Company.
Nelson, Lionel, Technical Assistant, East Hull Gas Company.
Newsome, Mark, Junr., Chief Chemist, County Borough of Blackpool Gas Department.
Richardson, James, Industrial Sales Technical Representative, Sunderland Gas Company.
Sheldrake, Thomas Wentworth Swinborne, Industrial Representative, The Gas Light and Coke Company.
Silcox, Arthur Leonard, B.Sc., Engineer and Manager, Saltash Gas and Coke Company, Ltd.
Stewart, William Alexander Muir, Engineer and Manager, Maryport Urban District Council Gas Department.
Sullivan, Harold Denis, Sales and Technical Superintendent, Plymouth and Stonehouse Gas Light and Coke Company.
Tomes, John Alfred, Chief Chemist, County Borough of Walsall Gas Department.
Watson, Frank, Chief Chemist, County Borough of Wallasey Gas Department.
Watson, Thomas, Acting Engineer and Manager, Rushden and Higham Ferrers District Gas Company.
West, David Emrys, Chief Technical Assistant, Port Talbot Corporation Gas Department.
Wilson, John Frederick, Works Technical Assistant, Perth Corporation Gas Department.
Winter, Dennis Arthur, B.Sc., Ph.D., Technical Officer, Radiation Ltd., Birmingham.
Witt, Alfred Leonard, Training Assistant, The Gas Light and Coke Company.

Associateship.

Wright, Patrick George, Staff Officer, The Gas Light and Coke Company.

Autumn Research Meeting

THE PRESIDENT,
Robert Robertson, M.Inst.C.E., M.Inst.Gas.E.

OF THE

INSTITUTION OF GAS ENGINEERS

Thirteen Reports and Papers were presented and discussed at the 10th Autumn Research Meeting of the Institution held in London on Nov. 1 and 2. Owing to the indisposition of the President, Mr. R. Robertson, the Chair was taken by Mr. G. DIXON, the Senior Vice-President. In the following pages we give abstracts of the various Communications together with a full report of the discussions to which their presentation gave rise.

4th Report of the Research Executive Committee; 1937-38

[ABSTRACT]

Communication No. 187

RESEARCH EXECUTIVE COMMITTEE

The members of the Research Executive Committee of The Institution of Gas Engineers for 1937-38 were:

E. V. Evans, O.B.E., F.I.C. (*Chairman*); H. C. Smith, M.Inst.C.E. (*Vice-Chairman*); Stephen Lacey, B.Sc., M.Inst.C.E. (*Honorary Secretary*); J. E. Davis; H. Hollings, D.Sc.; H. D. Madden, M.Inst.C.E., M.I.Mech.E.; C. A. Masterman, M.A., M.I.Mech.E., F.I.C.; T. F. E. Rhead, M.Sc., F.I.C.; E. W. Smith, C.B.E., D.Sc., F.I.C.; the President, the two Vice-Presidents, and the Honorary Secretary of the Institution (*ex-officio*).

Co-opted: Harold Hartley, D.Sc.

It is with regret that the Committee has to record the retirement of Professor John W. Cobb from the Livesey Professorship of Coal Gas and Fuel Industries at the University of Leeds. The Committee wishes to place on record its appreciation of the co-operation of Professor Cobb on the Joint Research Committee of The Institution of Gas Engineers and Leeds University and on the Liquor Effluents and Ammonia Committee of the Institution, and of the facilities accorded by him in the laboratories of his Department for the investigations of the Research Chemists and Research Assistants of the Institution.

Investigations

The Committee has continued its normal work of correlating the efforts of the several Technical Committees of the Institution and has been materially helped in this by the attendance at its meetings of the Chairmen of the Committees who have been able to report upon and explain in detail the progress being made. In addition, much thought has been given to the desirability of increasing the scope of the centralized research of the Gas Industry and of the most appropriate means of increasing the usefulness of the research organization of the Institution.

From time to time the Gas Industry has been criticized for the apparently small sum of money it expends on centralized research, and if regard be had only to those research workers under the direct control of Committees of the Institution it cannot be claimed that the research staff is strong in number, however able and keen it may be. It is recognized, however, that the greatest resources for research possessed by the Gas Industry are represented by the laboratories and technical staffs of Gas Undertakings and Firms of plant and appliance manufacturers. The generosity with which these resources are placed at the disposal of all within the Industry is not always appreciated as fully as it deserves to be, and it is true that much of the Institution's technical work could not be undertaken if it were not for the help so freely given. Nevertheless, it would be unwise to take it for granted that the whole field of possible effort is adequately covered without gaps or overlapping, particularly when it is remembered that the technical staff of a Gas Undertaking or of a plant or appliance manufacturer is necessarily preoccupied to a considerable extent by the need for a solution of pressing day-to-day problems. Thus it is that the Research Executive Committee has thought it of value to consider what steps might be taken to correlate the volume of work which is already proceeding, to supply what additional effort may be necessary to reinforce any possible weak points, and to provide a means whereby the accumulated and accumulating store of knowledge may be made more readily available for practical application.

With this in mind, and through the ready co-operation of Gas Undertakings and members of the Society of British Gas Industries, the Committee has recommended to the Council that a survey should be made of the resources for research existing within the Industry. Such a survey must form an essential preliminary to the preparation of plans for a greater co-ordination and development of research and the thanks of the Committee are due for the facilities which have been given.

As part of the same general plan added encouragement has been given during the year to organizations capable of

undertaking investigations likely to prove of value to the Gas Industry and, on the recommendation of the Committee, the Council has already voted funds for supporting five specific investigations:

(i) Problems relating to the ventilation of rooms in dwelling houses, offices and the like. So long as rooms were heated by solid fuel burning in an open fireplace adequate ventilation was ensured, but with the advent of other forms of heating which do not in themselves make a flue essential, the adequacy of ventilation may be called in question. In this study the Institution is fortunate in having the collaboration of the London School of Hygiene and Tropical Medicine.

(ii) Combustion tests during the development and testing of gas appliances have shown that the characteristic smell of "incomplete combustion" is not quantitatively associated with the production of carbon monoxide. Research into the reasons for this and other anomalous behaviour appears overdue in order to obtain a more complete understanding of the combustion process of town gas. Arrangements have accordingly been made for an investigation to be undertaken at the Chemistry Department of Cambridge University under the supervision of Dr. Hamilton McCombie, M.A.

(iii) The higher thermal efficiency and greater heat output demanded of gas fires and other gas appliances often carries with it a need for higher aeration, and for this and other reasons there is a greater tendency for noise to be produced with certain modern gas appliances compared with their predecessors. The origin and methods of diminishing these noise effects are not sufficiently understood, while the standard of performance demanded of gas appliances at the present time requires noiseless operation so far as can be attained. Towards the further elucidation of this acoustical problem work is being undertaken at the request of the Research Executive Committee by the National Physical Laboratory.

(iv) Acting on a suggestion originating from the Gas Works Safety Rules Committee, a recommendation was made that a study of the stresses in the Guide Rails and Rollers of Spirally Guided Gasholders should be undertaken in collaboration with the National Physical Laboratory. This has commenced and the facilities possessed by this Laboratory for experiments in wind tunnels will be available for the work.

(v) An investigation which has been undertaken, at the request of the Department of Scientific and Industrial Research, by the Research Council of the British Iron and Steel Federation, in co-operation with other furnace-using industries, into the fundamentals of furnace design and operation. This investigation is being carried out at the City and Guilds College, South Kensington, London, and The Institution of Gas Engineers is represented upon the Industrial Furnaces Research Committee which directs the work.

At Leeds University three Research Chemists and four (now five) Research Assistants were retained during 1937-38 for the conduct of investigations.

Technical developments at home and overseas continue to be watched and investigated.

The Committee is considering, at the request of the Industrial Gas Centres Committee, with which it maintains close contact, the desirability for investigations of refractory materials for gas-burning appliances, and as a first step a survey of the work which has been done on and the literature connected with this matter has been made.

Kindred Organizations

The Institution continues to take an active part in the work of the International Gas Union and its representatives have attended during 1937-38 the meetings of the Council and of the Bureau of the Union.

The Institution co-operates in the work of the Joint Committee on Materials and their Testing of Technical Institutions and Societies in Great Britain, the object of which is, *inter alia*, to promote joint discussions on matters relating to materials and their testing and to assist co-operating Institutions and Societies in the presentation of a paper or papers relating thereto. A meeting is to be held in London in the autumn of 1938 at which papers dealing with Non-Destructive Testing will be presented and discussed.

The Institution of Gas Engineers continues, through the Gas Industry Committee, Technical Committees, and otherwise, to co-operate with the British Standards Institution in the preparation of British Standard Specifications. Its thanks are due to its representatives for their assistance and time given to this work.

Advisory Committee on Research

The membership of the Advisory Committee on Research for 1937-38 was as follows:

President (Chairman), the two Vice-Presidents, Honorary Secretary, members of the Research Executive Committee, Chairmen of Technical Committees of the Institution and the Livesey Professor, all *ex officio:*

Robert Robertson, M.Inst.C.E. (*Chairman*); E. V. Evans, O.B.E., F.I.C. (*Vice-Chairman*); Stephen Lacey, B.Sc., M.Inst.C.E. (*Honorary Secretary*); F. M. Birks, O.B.E., M.I.Mech.E.; Charles F. Botley, M.Inst.C.E.; Prof. John W. Cobb, C.B.E., B.Sc., F.I.C.; J. E. Davis; George Dixon, B.Eng., M.Inst.C.E.; H. J. Escreet, B.Sc.Eng.; Walter Grogono; H. Hollings, D.Sc.; H. D. Madden, M.Inst.C.E., M.I.Mech.E.; C. A. Masterman, M.A., M.I.Mech.E., F.I.C.; T. F. E. Rhead, M.Sc., F.I.C.; E. W. Smith, C.B.E., D.Sc., F.I.C.; H. C. Smith, M.Inst.C.E.; John Terrace, M.Inst.C.E.; Sir Frederick J. West, Kt., C.B.E., J.P.

Representatives of Government and University Fuel Research and others having a special interest in Research:

H. T. Calvert, M.B.E., D.Sc., Ph.D., F.I.C.; Sir Christopher Clayton, Kt., C.B.E., J.P.; W. A. Damon, B.Sc., F.I.C.; Prof. A. C. G. Egerton, M.A., F.R.S.; Margaret Fishenden, D.Sc.; Sir Francis Goodenough, Kt., C.B.E.; A. T. Green, F.I.C.; Sir Harold Hartley, Kt., C.B.E., M.Sc., F.R.S.; Harold Hartley, D.Sc.; James Jamieson; Frank H. Jones; Prof. C. H. Lander, C.B.E., D.Sc.; H. McCombie, M.A., Sc.D.; J. W. McLusky, M.I.Mech.E.; Prof. Sir Gilbert Morgan, Kt., O.B.E., D.Sc., F.R.S.; A. Parker, D.Sc., F.I.C.; F. B. Richards, M.B.E., M.Inst.C.E., M.I.Mech.E.; F. S. Sinnatt, C.B., M.B.E., D.Sc.; Sir Frank E. Smith, K.C.B., C.B.E., D.Sc., Sec.R.S.; Prof. Arthur Smithells, C.M.G., D.Sc., F.R.S.; J. W. T. Walsh, D.Sc.; C. M. Walter, D.Sc.; Henry Woodall, J.P.

National Gas Council Nominees:

President (*ex-officio*); Sir David Milne-Watson, Bt., M.A., D.L., LL.D.; W. J. Sandeman, J.P.; A. W. Smith.

British Commercial Gas Association Nominees:

President (*ex-officio*); A. M. Paddon; T. P. Ridley; J. Sandon Stubbs.

Society of British Gas Industries Nominees:

Chairman (*ex-officio*); Colonel O. B. F. Planck, D.S.O., D.L.; H. M. Thornton, J.P.; Ernest West.

The Advisory Committee on Research held its second annual Meeting on 3rd December, 1937.

The Committee meets to receive and consider the Annual Report of the Research Executive Committee and to discuss, on broad lines, the research requirements of the Gas Industry. For the guidance of the Research Executive Committee, it reviews the trend of technical development in all its aspects, but it has no responsibility for the details of research, personnel, finance or organization.

Joint Lighting Committee

The membership of the Joint Lighting Committee for 1937-38 was as follows:

Institution Nominees: Stephen Lacey, B.Sc., M.Inst.C.E. (*Chairman*); A. Maurice Bell; W. J. A. Butterfield, M.A., F.I.C.; W. J. G. Davey, B.Sc.; Harold Davies; J. E. Davis; George Dixon, B.Eng.; E. V. Evans, O.B.E., F.I.C.; J. Weatherall Foreman; A. G. Higgins; A. L. Holton; James Jamieson; A. R. McGibbon; C. A. Masterman, M.A., M.I.Mech.E., F.I.C.; F. C. Smith; W. L. S. Spinks; C. I. Winstone.

Society of British Gas Industries Nominees: W. R. Edgar; Colonel C. J. Falk; F. J. Gould; J. H. G. Horstmann; C. H. A. Kempton; R. J. Rogers; H. R. Stevenson; Philip H. Sugg.

Affiliated District Gas Associations Nominees: James Dickson (North British); E. M. Edwards (Wales and Monmouth-

shire); E. Howard (Midland); F. G. McElwee (Irish); H. Singleton (Manchester); W. S. Stredwick (Southern); J. E. White (North of England); George Wright (Eastern Counties).

Ex-officio: The President, the two Vice-Presidents, and the Honorary Secretary of the Institution.

The Committee has given particular consideration during the past year to matters relating to the maintenance and extension of Public Lighting by Gas. For this purpose its membership has been increased to include representatives of each Affiliated District Gas Association, and at the same time District Associations have been urged to set up Lighting Committees to study local conditions. The Committee regrets to report the death of one of its members, Mr. J. R. Hepple (Newcastle-upon-Tyne).

The Committee, which has met regularly throughout the year, has continued to examine, with the assistance of its Technical Sub-Committee, the possible initiation of useful research into problems relating to Gas Lighting, with particular reference to increasing the efficiency of gas burners, mantles and switches.

The Committee maintains close contact with the Air Raid Precautions Department of the Home Office concerning lighting restrictions in time of war. A Memorandum on Lighting Restrictions was published by the Home Office in February, 1938, intimating that there would be no lighting in time of war and this policy still remains unchanged. The Memorandum, together with a covering letter from the Chairman of the Committee, was sent to all Gas Undertakings.

The Final Report of the Departmental Committee on Street Lighting of the Ministry of Transport, which was published in the autumn of 1937, was circulated to all Gas Undertakings, together with a booklet, "Light on the Roads", prepared by the British Commercial Gas Association and dealing with the recommendations of the Departmental Committee.

In March, 1938, members of the Committee gave evidence regarding Factory Lighting by Gas, by invitation, before a Departmental Committee on Lighting in Factories and Workshops which was set up in connexion with the Factories Act, 1937.

A draft Standard Specification for Low-Pressure Gas Mantles has been completed by the Committee in collaboration with representatives of the mantle makers, and has been passed to the British Standards Institution as the suggested basis of a new British Standard Specification. A Committee of the British Standards Institution has been set up in this connexion and has issued a draft Specification for comment.

The revised British Standard Specification for Street Lighting has also been issued in draft form for comment.

Liquor Effluents and Ammonia Committee

The membership of the Liquor Effluents and Ammonia Committee for 1937-38 was as follows:

C. F. Botley, M.Inst.C.E. (*Chairman*); T. Lewis Bailey, Ph.D., F.I.C.; H. T. Calvert, M.B.E., D.Sc., Ph.D., F.I.C.; W. A. Damon, B.Sc., F.I.C.; E. V. Evans, O.B.E., F.I.C.; H. Hollings, D.Sc.; P. N. Langford; P. G. G. Moon, M.Inst.C.E.; A. Parker, D.Sc., F.I.C.; P. Parrish, F.I.C.; E. W. Smith, C.B.E., D.Sc., F.I.C.; W. W. Townsend; J. Wilkinson, O.B.E.; Prof. J. W. Cobb, C.B.E., B.Sc., F.I.C. (*Honorary Secretary*); the President, the two Vice-Presidents, and the Honorary Secretary of the Institution (*ex-officio*). *Co-opted*: Leslie F. Stemp, B.A.

The Committee has met regularly during the year, but has conducted no special investigations or research. Dr. Arthur Key (Research Chemist) has been engaged on other investigations at Leeds University, but his services have been available to the Committee when required.

Special attention has been given to the compilation of the separately published book entitled "Gas Works Effluents and Ammonia", prepared by Dr. A. Key. This book comprises not only a summary of the work and investigations of the Liquor Effluents and Ammonia Committee and its predecessors of the Institution, but a comprehensive review of the present state of knowledge regarding the various problems connected with the recovery and utilization of gas works ammonia and the disposal of effluents therefrom. The book, to which all members of the Committee have directly or indirectly contributed, should prove of permanent value to gas engineers and others interested in the subject treated or confronted with problems connected with it.

The new Drainage of Trade Premises Act, which came into force on 1st July, 1938, and may have important effects on the Gas Industry, has been considered and representations have been made in respect of certain clauses of the Draft Model Byelaws proposed by the Minister of Health in respect of Section 5 of the Act.

The Committee has also considered the First Report of the Central Advisory Water Committee, in particular Appendix C thereof containing suggested alterations to Sections 61 and 62 of the Waterworks Clauses Act, 1847. The suggested alterations, if confirmed and incorporated in future legislation, provide specific penalties for permitting substances produced in making gas to flow into a stream or works of a water undertaking or into the subsoil in the vicinity of wells or adits belonging to water undertakings.

The Committee keeps in touch with other bodies and considers any ways in which it can be of service in the particular matters with which it is concerned. Information and assistance have been given, as usual, to many enquirers seeking guidance or in difficulties. It is not possible to give details of such enquiries, but the following typical instances may be mentioned:

(1) Pollution of a public water supply was traced to leaky tanks and pipes on an adjacent Gas Works.

(2) Trouble, which had arisen in connexion with a sewer carrying crude liquor to a sewage works, was investigated and a satisfactory solution agreed upon.

(3) An interesting case was considered in which, although liquor effluent had been treated at a sewage works for many years without difficulty, trouble suddenly arose which was attributed by the Local Authorities to the liquor. It was demonstrated that the trouble was not due to the liquor.

Frequent enquiries are received regarding the disposal of liquor. There is still a tendency to dispose of crude liquor by way of the sewers, which is deprecated by the Committee.

The general recommendation still holds good, that concentration of liquor is the best method of disposal, since the effluent from liquor concentrating plant is less difficult to deal with than crude liquor. A combination of Undertakings in different localities throughout the country for the purpose of operating concentrating plants should be possible.

Mr. E. V. Evans, introducing the Report, said: In presenting to you the Fourth Report of the Research Executive Committee I hope that you will approve of the carefully considered recommendation of that Committee to deal with this item at the commencement of the Autumn Research Meeting rather than at the end, as has been customary in recent years. We considered it to be more logical that members should be given the opportunity of considering and discussing the larger question of the general technical work of the Institution before they turn to the more detailed matters dealt with in the Reports of the several Committees and in the contributed Papers.

The Research Executive Committee naturally hopes that the Report now presented will meet with your approval and believes that it shows an appreciably extended field of work, but it will be disappointing if the Report does not call forth some constructive criticism either by discussion or by written communication to the Secretary. We cannot consider that we are making a sufficient research effort until every progressive member feels that his problems have already been solved or are receiving attention. Even that alone would not be enough, because the Gas Industry cannot afford to stay still and technical progress needs foresight and careful planning of exploratory research.

How best to meet these demands is a problem that your Committee cannot solve without your individual interest, your encouragement, and your co-operation. Its members have

their own knowledge and special experience and I could not wish to be supported by an abler and keener body of men, but they cannot know of all your difficulties and all your problems unless you are willing to invoke their aid.

Through the several Committees responsible to it, the Research Executive Committee endeavours to collect together expert knowledge upon groups of related problems. The most recently formed of these Committees is one which is trying to clarify and to bring law and order into that most contentious matter of unaccounted-for gas. Then, through the Joint Research Committee and by contact with research associations, universities, and other technical bodies outside the Institution, it initiates and directs investigations into matters which are, or are likely to become, of interest to our Industry. As examples of investigations that have been recently instituted, we are collaborating with the London School of Hygiene on the question of ventilation, and with Cambridge University on the problems of minute deviations from complete combustion. Other problems are receiving consideration in this way but I should like especially to mention our Joint Committee with the Fuel Research Board upon the general subject of methane synthesis. While this Institution is devoting its attention to the synthesis of methane under pressure during the carbonizing process, the Fuel Research Board is more concerned with the production of methane at ordinary pressures and in the presence of a catalyst. Their discovery of a catalyst which acts effectively in the presence of sulphur-containing gases is one of great importance. The Fuel Research Board accepted an invitation to present the results of their work in this matter at this meeting, and I am sure that you will welcome their interesting communication. Such joint and co-ordinated work is essential to progress, and I can promise you that there is to be a good deal more of it in the future. I think it is already generally known that Dr. Braunholtz has recently made a survey of research in the Gas Industry. The Report, which is a most interesting and ably produced document, shows that our Industry—and by this I mean not only the supply side of the Industry but also the plant and appliance manufacturer—is very fully alive. That there is a large volume of work of excellent quality being done is shown by the reports circulated to this and to other research meetings, but so long as the work is conducted in separate laboratories by separate workers, under a direction that is not co-ordinated, there is a risk of overlapping in some directions and of serious gaps in others. Of necessity the research staff of a gas undertaking or of a manufacturer of plant or appliances is largely concerned with problems of immediate interest to that business, but out of such studies there will, from time to time, arise observations of wider importance but of less obvious significance. In the press of more urgent work such observations may be shelved, but it would be far better if they could instead be brought to the notice of those who may have more time and facilities to develop further such observations.

Need for Co-Ordination.

Co-ordination of some kind would appear to be urgently necessary but we must be careful to see that whatever is done should not disturb that freedom which allows individuality its full play. We are most adamant about this. It would be a disaster to adopt bureaucratic methods in the control of research work, and it is clearly undesirable to hamper any worker from acquiring an advantageous competitive position for his employer.

Reverting to my remarks in the earlier part of this presentation, I should not like to leave the impression that your Research Executive Committee is unduly pleased with itself or that it feels that everything in the garden of research is in a healthy condition. It would be representative of a sad state of affairs if we developed such smugness. There is an immense amount of work waiting to be done and the problem of the immediate future is so to co-ordinate our efforts that that work may be done in the most effective way.

From this Report you will have gathered that the contact of the Institution with the universities as research centres is becoming wider and it is to be hoped that we may in time build up associations with these other centres of learning as happy and as fruitful as our long association with the University of Leeds. The success of the collaboration between this University and the Institution has been in no small measure due to the personality of the men who have occupied the Chair of the Livesey Professor.

Our regret at losing Professor Cobb from this position, through his retirement at the end of September, is tempered by our pleasure in welcoming such an able successor as Professor Townend. Of Professor Cobb's achievements as a scientist there is no need for me to speak for they are well-known to you, but as one who has worked with Professor Cobb on the Joint Research Committee of the Institution, I would pay tribute to the personality that has made such collaboration a real pleasure. It would be a great misfortune if Professor Cobb's retirement meant also the severance of his connexion with the research work of the Institution, and I am sure that we shall endeavour to induce him to continue to work with us. It is imperative that his shrewd judgment and wide experience continue to remain at the service of the Gas Industry. Professor Townend comes to us as a disciple of the first Livesey Professor and in his studies upon the combustion of gases and the nature of flame he has shown how much the fundamental problems that interest the Gas Industry are his interest too. Indeed, it may be said that the University of Leeds and the Gas Industry are both to be congratulated upon the Livesey Professors, both past and present.

Further Extending the Work.

Colonel W. M. CARR (United Kingdom Gas Corporation): As a member of the Council I naturally do not wish to cross swords with the Research Executive Committee, as from time to time I have had opportunities, with other members, of putting forward any suggestions or any remarks that I might have to make. I would, however, like to take this opportunity of suggesting to our Research Executive Committee the possibility of further extending their work particularly in view of the reorganization that is taking place, and which is being considered, at the present moment by the National Bodies as a whole. I feel that a weakness in our research organization in the past has been that the practical problems which give rise to the necessity for certain lines of research have not been sufficiently co-ordinated with the work of the Research Executive Committee. In the Report it is pointed out that the problems relating to the ventilation of rooms in dwelling houses, offices, and the like have been the subject of, and are the subject of, work in collaboration with the London School of Hygiene. My experience has been that that work so far as ventilation is concerned is important, but there is still a tremendous amount of work to be done in the matter of conductivity, of the amount of heat requirement, and then the more practical applications following that—namely, the efficiencies of various fuels applied to the problem of space heating. I make this suggestion because one receives from time to time reports from heating engineers—capable heating engineers—that vary enormously in the estimation of the efficiency of fuels. To give you a practical example of what I mean, one case that came to my notice was the heating of a large building and the heating engineer and the architect estimated that the requirements and the cost of gas based upon their estimation of the installation would be three times as much as the actual cost when it was worked out in practice. Again, I have heard of a case in which gas has been turned down by the Minister of Education in a particular application in favour of solid fuel, which was given the preference, and I am certain in my own mind that that was due to a complete misunderstanding of the relative efficiencies, knowing as I do that gas was offered at a very low price in that instance. Therefore, I have wondered, and I put it forward as a suggestion, whether some practical collaboration with the Institution of Heating and Ventilating Engineers might not be introduced on this question of efficiencies of various appliances. It would help from a publicity point of view. Of course, I appreciate that this is coming more to what one might consider practical research rather than fuel research and possibly it might be better effected by a closer liaison between the Industrial Gas Development Centres of the Research Executive Committee. However, I take this opportunity of putting forward that suggestion as just being a further line of thought on the work that is at present being done by the Committee.

Mr. E. V. EVANS (Chairman of the Research Executive Committee): All I can say in reply is that we shall give careful consideration to Colonel Carr's suggestion.

42nd Report of the Joint Research Committee of the Institution and Leeds University

Combustion Characteristics of Town Gas. Part III.—Properties and Method of Use of the Aeration Test Burner (Model A)

Research Chemist: James W. Wood, M.Sc.Tech., A.I.C. *Research Assistant*: A. H. Eastwood, Ph.D., A.I.C.

[ABSTRACT]

Communication No. 189

Second only in importance to the amount of heat generated is the manner in which a gas burns, and the greater part of the 40th Report of the Joint Research Committee* was devoted to an examination of the literature of the subject in order to see if a quantitative expression for "combustion characteristics" had been, or could be, developed. Because of the complexity of the problem there seemed little likelihood of deriving a fundamentally sound formula for expressing combustion characteristics that would be sufficiently simple, rapid, and accurate for everyday use. As an alternative it was thought that the combustion of a gas in a standard burner might possibly give a serviceable indication of its combustion characteristics.

After consideration of the several types of test burner available, the Aeration Test Burner was chosen as representing perhaps the best compromise between the requirements for laboratory and works use. The 40th Report contained a description and the results of a preliminary examination of one of these instruments. Investigation of the A.T.B. has continued both at Watson House and by the Joint Research Committee, the chief conclusion being that the burner must be produced to a more rigid specification than has hitherto been the case if uniformity in results is to be obtained. Certain improvements are proposed, but they are in mechanical arrangement rather than in the principles of operation of the instrument. The suitability of this type of instrument for assessing combustion characteristics of gas is, however, still *sub judice*.

In the meantime some 50 of these burners have been purchased by Undertakings and put into use in various parts of the country, in the belief that they would assist in the control of gas quality, and it was therefore considered that a good purpose would be served by preparing a memorandum pointing out the precautions to be observed in order to attain uniformity and reliability in use of the current model of the Aeration Test Burner.

PRECAUTIONS TO BE OBSERVED IN THE USE OF THE AERATION TEST BURNER (MODEL A)

The following notes have been prepared for the guidance of those using the Aeration Test Burner to supplement the instructions issued by the makers of the instrument, and the information given in the 40th Report of the Joint Research Committee.†

1. The Aeration Test Burner should be used in a well-ventilated room, free from draughts. In particular, the CO_2-content of the air should not exceed 0·2 per cent. and care should be taken to avoid breathing near the air-intake to the burner whilst making observations. A situation as free from dust as possible should be selected. Observations can be made most conveniently in subdued daylight but enough light must be available to illuminate clearly the fiducial line on the mirror.
2. The burner should be connected to a gas supply at a pressure of not less than 3 in. w.g. The pressure at which the burner was calibrated is shown by a red line on the gauge and should be reproduced within − 0·05 to + 0·15 in. w.g. In order to fix the pressure within these limits the gauge glass must be maintained in a scrupulously clean condition internally. As the working pressure varies slightly with the inlet pressure to the governor, it may be necessary to use an auxiliary cock or screwclip outside the instrument case in order to secure the desired working pressure. Long lengths of rubber tubing should be avoided in connecting up the burner.
3. The supply of water to the burner head is not critical, but it is recommended that it be kept between 10° and 20° C. at the inlet, whilst a flow of between say 200 and 500 c.c. per min. will be found convenient.
4. The instrument is adjusted by slowly opening the air-shutter until the tip of the inner cone of the flame is brought down to the fiducial mark on the mirror, which is used in the conventional manner to eliminate parallax.
5. Readings may be taken 5 min. after lighting the burner. There will generally be some slight oscillation of the inner cone of the flame, but it is not difficult to determine the mean position of the tip of the cone with reference to the fiducial line. Normally, readings will be easily reproducible within ± 0·5 division on the A.T.B. scale, and frequently within ± 0·2 division. Readings above 120 on the scale are practically useless.
6. The zero of the instrument should be checked weekly by removing the stop-peg below the dial and gently turning the latter until contact is made with the lower face of the air-intake cone. An alternative is to place a lamp behind the burner and, with the eye on a level with the air-intake cone. An alternative is to place which light is cut off. Variations in zero reading to the extent of ± 0·5 scale division may be disregarded. On the other hand, the dial has been known to slip on its lock-ring giving a large zero error, necessitating resetting by the makers. Parallelism of the air-slot should also be checked when observing the zero setting.
7. The air-slot should be cleaned with a folded slip of fluffless filter paper at least weekly. (Whatman No. 42 is suitable.) In dusty situations, or where the burner is alight for long periods, cleaning may be necessary every two or three days.
8. From time to time the position of the lower mark on the mirror with respect to the tip of the burner should be checked, so that the correct cone height may be maintained.
9. The instrument is reasonably robust but must be treated carefully in order that its calibration may remain unaltered. The scale of the instrument is empirical and there is no means whereby the user can check or re-set it. The burner should therefore not be taken apart for cleaning, if this can be avoided, as the calibration chart may thereby be invalidated. The calibration can be affected by displacement of the several parts of the burner, and by accumulation of dust in the gas nipple, air-slot, or in the burner stem. It is therefore recommended that the instrument be returned to the makers at intervals of six months for cleaning and re-calibration.
10. The value of the readings of the A.T.B. can be enhanced if simultaneous readings of calorific value and specific gravity of gas are also recorded.

* *Inst. Gas Eng. Comm. No.* 166 (1937).

† *Inst. Gas Eng. Comm. No.* 166 (1937), 57–58, 67–69.

THE A.T.B. NUMBER OF LEEDS TOWN GAS

Few systematic observations of the A.T.B. Numbers of public gas supplies have been published up to the present time* and it is therefore difficult to form an estimate of what may be regarded as a typical or reasonable degree of variation.

Whilst the examination of the Burner was in progress, daily readings were taken on two streams of gas at the Meadow Lane Works of the City of Leeds Gas Department and the results of these are now made known by permission of Mr. C. S. Shapley, the Engineer and General Manager. It should be pointed out that the gas making process throughout the period in question was controlled in the normal manner to produce gas to the declared calorific value for Leeds, namely, 470 B.Th.U. per cu.ft., and no conscious effort was made to work to a constant A.T.B. Number.

The results are indicated in Table 1. Those of the upper part of the table are for the town gas stream. This is produced by steaming in West's 33- and 50-in. retorts and is partially washed for benzole but not dried. During the greater part of the period covered (nearly 3 months) carburetted water gas was added to the coal gas. The results in the lower part of the table were obtained on a stream of gas made available for experimental purposes, taken at the outlet of the benzole plant and before the addition of the water gas.

It will be observed that the variation of the A.T.B. Number of the town gas during the period was less than ±5 units, and that the addition of carburetted water gas lowered the A.T.B. Number of the coal gas by about 5 units. The unexpected result that the gas at outlet benzole plant showed a somewhat greater variation than the town gas is doubtless due to the fact that these tests were made before the holder, and the gas was therefore deprived of the valuable mixing and balancing effects which take place therein. The nature of the variation in specific gravity of the two streams of gas is also indicated in the table.

TABLE 1.—*Variation in Quality of Leeds Town Gas, May to July, 1938*

——	Mean.	Maximum.	Minimum.	Difference Between Max. and Min.
1	2	3	4	5
I. Town Gas Supplied to Office Building:				
A.T.B. Number	62·3	66·0	57·6	8·4
Specific gravity	0·482	0·511	0·453	0·058
Calorific alue	471	—	—	—
Proportion of A.T.B. observations falling within ± 2 units of average value	82·0 per cent.			
II. Gas at Outlet Benzole Plant, without c.w.g.:				
A.T.B. Number	67·8	73·0	63·3	9·7
Specific gravity	0·449	0·474	0·421	0·053
Calorific value	470	—	—	—
Proportion of A.T.B. observations falling within ± 2 units of value	65·1 per cent.			

* *See* 40th Report of Joint Research Committee, p. 50; and Stredwick, W. S., and Thorne, W. F., "A.T.B. Number Control of Town Gas", *Gas J.*, 1938, **222**, 368.

EFFECT UPON A.T.B. NUMBER OF ADDING VARIOUS CONSTITUENTS TO LEEDS TOWN GAS

For projected experimental work upon the relationship between the A.T.B. Number of gases and their behaviour in ordinary appliances it will be necessary to prepare gas mixtures of different compositions. A series of experiments was therefore made in order to examine the possibility of modifying the composition of the available Leeds town gas in various ways, and the results are indicated in Figure 1. The left-hand bottom corner of Figure 1 is enlarged in Figure 2 to show more clearly the relative effects of different inerts and rich hydrocarbons upon the A.T.B. Number. The numbers attached to the plotted points identify the mixtures of Table 2. The composition of the basic gas is indicated approximately in column 2 of Table 3.

It is evident that inerts, without exception, caused a lowering of the A.T.B. Number, and that the depression was different for equal volumes of nitrogen, carbon dioxide, air, and oxygen, increasing in that order. It is, however, important

TABLE 2.—*Effect of Mixing Various Gases with Leeds Town Gas*

Key to Gas Mixtures of Figures 1 and 2

Gas Reference No.	Nature of Mixture.	Calorific Value, B.Th.U. per Cu.Ft. Gross.	Specific Gravity, Sat. Air at 60° F. and 30 In. Barometer = 1.	A.T.B. Number of Gas.*
1	2	3	4	5
70	Leeds town gas,† 45 per cent. + rich coal gas,‡ 55 per cent.	559	0·437	121·0
71	" " " 50 " + " " " 50 "	552	0·424	113·9
72	" " " 55 " + " " " 45 "	542	0·440	109·6
73	" " " 60 " + " " " 40 "	531	0·442	94·0
74	" " " 77·8 " + " " " 22·2 "	507	0·436	75·3
75	Leeds town gas, 95·5 " + calor gas,§ 4·5 "	593	0·518	106·6
76	" " " 96·25 " + " " 3·75 "	572	0·507	94·1
77	" " " 97·5 " + " " 2·5 "	538	0·492	79·5
78	Leeds town gas, 98·2 " + benzene vapour, 1·8 "	514	0·492	75·3
79	" " " 98·9 " + " " 1·1 "	492	0·480	69·6
83	Leeds town gas, 40·0 " + hydrogen, 60·0 "	380	0·232	49·8
84	" " " 35·5 " + " 64·5 "	373	0·221	47·2
85	" " " 76·7 " + " 23·3 "	435	0·364	61·1
86	Leeds town gas, 50·0 " + theor. b.w.g., 50·0 "	394	0·482	37·6
87	" " " 75·0 " + " " 25·0 "	432	0·467	50·5
88	Leeds town gas, 95·4 " + acetylene,¶ 4·6 "	515	0·464	66·9
90	Leeds town gas, 95·0 " + oxygen, 5·0 "	447	0·479	47·8
91	Leeds town gas, 94·6 " + carbon dioxide, 5·4 "	447	0·507	57·8
92	" " " 88·4 " + " " 11·6 "	416	0·570	51·7
89	Leeds town gas, 91·1 " + air, 8·9 "	427	0·502	51·8
93	" " " 81·6 " + " 18·4 "	384	0·543	41·4
94	Leeds town gas, 80·3 " + nitrogen, 19·7 "	377	0·538	47·3
95	" " " 89·0 " + " 11·0 "	420	0·502	53·5
96	Leeds town gas, 85·0 " + carbon monoxide, 15·0 "	449	0·529	51·5
97	" " " 92·4 " + " " 7·6 "	461	0·492	57·1
80	Theor. b.w.g., 100·0 "	317	0·528	19·0
81	" " 95·0 " + calor gas,§ 5·0 "	461	0·601	42·6
82	" " 90·7 " + " " 9·3 "	585	0·658	61·4

* The A.T.B. Numbers plotted on Figures 1 and 2 are the direct readings on A.T.B. No. 133. In column 5 the corrected values after the application of calibration and zero correction are given.
† Approximate composition, etc., shown in Table 3, column 2.
‡ " " " " " " 3.
§ " " " " " " 4.
Theoretical blue water gas—a synthetic 50/50 CO/H_2 mixture.
¶ Dissolved acetylene, supplied by the British Oxygen Company for welding purposes.

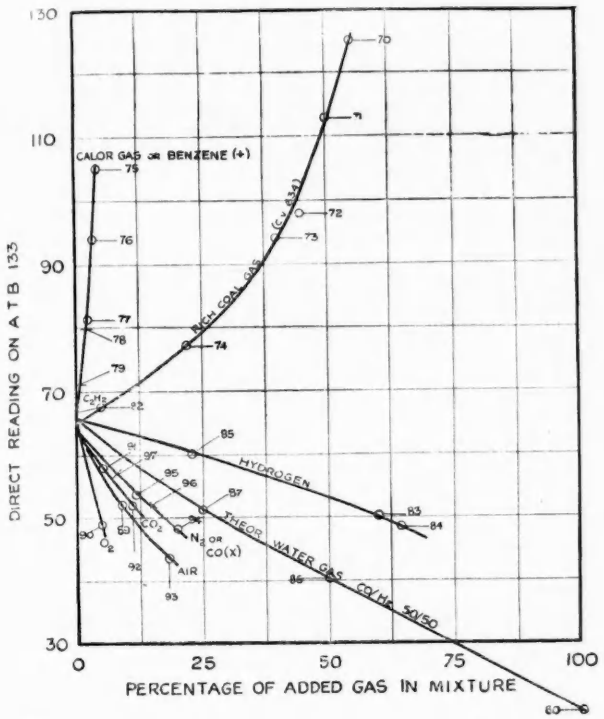


FIGURE 1.—*Effect of Adding Various Gases to Leeds Town Gas (Meadow Lane Works—C.V. 470).*

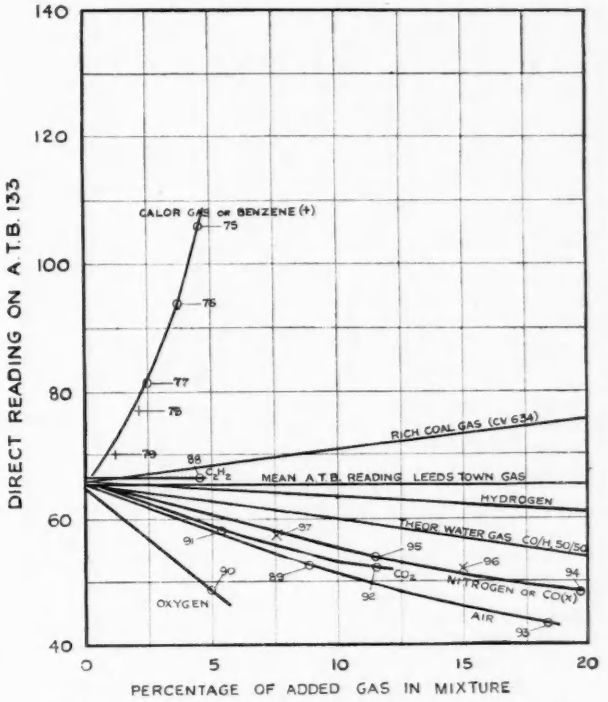


FIGURE 2.—*Effect of Adding Various Gases to Leeds Town Gas (Meadow Lane Works—C.V. 470).*

(Enlargement of Left-Hand Corner of Figure 1)

to note that in these experiments the composition of the combustibles was unaltered and the calorific value of the gas therefore fell in proportion to the amount of inerts added.

In normal Gas Works practice it would be necessary, in order to comply with statutory requirements as regards calorific value, to correct for inerts by modifying the character of the combustibles. In certain trials he has made, H. Hollings found that if the calorific value is maintained constant, an increase in the inerts-content of a gas means an increase and not a decrease in the A.T.B. Number. It will be observed that in the above experiments the addition of CO_2 to the gas alters the A.T.B. Number in the opposite direction to the addition of CO_2 to the atmosphere around the burner. The comparatively small effect of the addition of hydrogen will be noted, despite the high rate of flame propagation in mixtures of that gas with air.

TABLE 3.—*Composition, etc., of Gas Used in Tests of Table 2.*

—	Leeds Town Gas.	Rich Coal Gas.	Calor Gas.
1	2	3	4
Analysis, per cent.:			
CO_2	3·1	0·1	—
O_2	1·0	0·1	—
C_mH_n*	1·75	4·8	—
CO	13·2	9·4	—
H_2	53·2	49·3	—
C_2H_6	2·2	1·5	—
CH_4	17·05	31·8	—
N_2	8·5	2·9	—
Propane	—	—	5·0
Butane	—	—	78·0
Isobutane	—	—	17·0
Total	100·00	99·9	100·0
Calorific value *B.*Th.U. per cu.ft.:			
Determined	470	634	3,200
Calculated	460	641	—
Specific gravity†:			
Determined	—	—	1·98
Calculated	0·453	0·424	—
A.T.B. Number	63	—	—
Air required, cu.ft. per cu.ft. gas:			
Calculated	3·89	5·70	31·0.
Carbon dioxide production, per cent.:			
Determined	43·2	56·8	380·0
Calculated	43·0	58·7	—
Water vapour production, per cent.:			
Calculated	99·1	131·8	—

* C_mH_n.—Assumed as equivalent to propylene, C_3H_6, *i.e.*, C.V. = 2,300 B.Th.U. per cu.ft.; sp.gr. = 1·446; air requirement = 21·42 cu.ft. per cu.ft. gas.

† Sp.Gr.—Determined values by Alexander Wright's Sp.Gr. Bell and corrected to 60° F., 30 in. bar., wet.
Calculated values on basis of saturated gas at 60° F., 30 in. bar. (Saturated air at 60° F., 30 in. bar. = 1)

Mr. H. C. SMITH presented the Report.

Professor J. W. COBB, having expressed his thanks for the kind remarks made concerning him, said: Reference has been made to the collaboration with the University in this research work, and I believe and hope that that association has been very fruitful. I am quite certain that there are very few of my audience who realize the fundamental difference between the position of the Gas Industry as regards research work and technical information at the present day and the position that obtained near the end of the war when, one might say, the Industry woke up, as an Industry, to the necessity for research. At that time it so happened that the position of various industries with respect to fuel economy came under national review, and the position of the Gas Industry had to be justified. The Industry had to take stock of what its real position was and how that position might be rendered firmer not only in its own interests but in the interests of the nation. At that time the Industry set out to state its position, and it so happened that the late Sir Dugald Clerk and Professor Smithells, together with myself, were commissioned to draw up for the use of an influential committee a statement of the kind that would show how strong was the position of the Gas Industry as one utilizing the fuel resources of this country. When we set to work and attempted to make a specific statement as to what became of coal as a source of energy and of chemical products, it was easy up to a point, but we found an astonishing lack of really reliable fundamental information under these heads. It was a surprise to us and to the Committee which I mentioned as being concerned directly with the drawing up of the statement we desired to make. Moreover, at the same time that the Gas Industry

was seeking greater powers, greater elasticity, in its own processes and wished to make definite statements as to what the actual performance was of gas made in different ways, again we found a complete lack of reliable information as the result of their enquiries. That was the starting point of work which has proceeded ever since—not of a spectacular character but carried out with the intention of laying firm the foundations of the Gas Industry by obtaining positive quantitative information as to gas manufacture and the utilization of gas instead of having to rely upon qualitative and often speculative information which had been available before. If you remember, the work was then divided into two parts. To begin with, there was the investigation of the efficiency of different grades of gas in lighting and that was followed by an examination of the manufacturing efficiency of gas and particularly of gas in vertical retorts with steaming. That, however, was only the beginning. The other processes of the Gas Industry had to be investigated, and one by one I think we may claim that they have been so investigated, that thermal and chemical balance sheets are now available in connexion with these processes. When that is done, it is not merely that the information is forthcoming to be produced in support of any statement that it may be desirable to make. The analysis of a process such as that of gas-making in any particular way, by giving positive quantitative information, lays bare what weaknesses may exist and is one of the most direct stimuli possible to the improvement of processes in the directions which have been indicated as desirable by the critical examination given to the process. That is the kind of work that has been going on. It has been done in association with the University of Leeds and I hope that the same successful collaboration will continue. I hope also that the support which has been given to me and the staff at the Leeds University may be continued and, indeed, strengthened, because a little appreciation goes a long way in bringing out the best of any such staff engaged in research work or anything else. That support which has been given to me will, I feel sure, be extended to Professor Townend, and I know, from what he has said to me and from what I now know of him, that the Gas Industry will be well served by my successor.

Mr. JAMES W. WOOD then introduced the Report.

Discussion.

Professor D. M. NEWITT: For ten years or more I have been engaged in work on the flow of gases and some of the results we have obtained seemed to have a bearing on the design of this aeration test burner. In the very able Report that Mr. Wood produced a year ago he made some very significant observations with regard to the working of the burner. To the best of my recollection, he found that the air/gas ratio was not proportional to the shutter setting, and that there was no very definite relation between the air/gas ratio and the pressure of the gas. These observations led him to conclude, quite rightly, that a more rigid specification with regard to the construction of the burner was necessary and in the present Report he has given some details of the various modifications that have been made in regard to dimensions and so forth. Of course, it is easy to criticize the design of a burner of this type, but it is extraordinarily difficult to make a reproducible burner. It is a matter of the very greatest difficulty to get an instrument that will deal with a combustible like coal gas where so many variables are concerned and give a reproducible figure, so that any criticisms I am making are not made without careful thought and without a full appreciation of the difficulties concerned.

The first point about this aeration test burner is that it acts as an injector, and one must consider it first in the light of an injector. Both Mr. Wood and Dr. Eastwood have pointed out that in this respect its efficiency is not good, and they have, I notice, now altered the position of the jet and have altered the methods of making the orifice, but I am still in some doubt myself as to whether an orifice is the best form of jet to use in a burner of this type. I think anyone who has tried to make reproducible orifices and to use them in the study of gas flow, will realize what queer things they are, and how difficult it is to make them. I do not feel at all convinced that punching a hole in a thin sheet of metal is a very good method, and I note an observation that the readings of the burner will vary according to the way you mount the orifice, whether it is in the direction of the punch mark or in the opposite direction. An orifice also has another effect upon gases passing through it which is not desirable in a burner of this type, and that is that it sets up various compression waves which are reflected in the stem of the burner, and I should think very likely give rise to the phenomenon that was noted by Mr. Wood—namely, the vibration of the cone. I think myself, in spite of a great deal that has been said on the subject of turbulence, that the condition one wants to arrive at in this burner is purely a streamline condition, and that one ought to be satisfied to obtain mixing not by turbulence but by a process of diffusion as the gas goes up the stem. In this connexion, Mr. Hodsman made a very interesting suggestion in the last Report, and that was with regard to the form of the shutter. He said, I think very clearly, that there would be distinct advantages in having the movement in the direction of the longer axis, and I do not think there can be any doubt that that is a very considerable improvement over the present type. At the same time, I think he might have gone a step farther and arranged also to have the shutter of such a form that the injected air is travelling in the same path as the gas and does not impinge on it and create turbulence.

Burner Mounting.

I feel rather sorry that the diagram of the burner in its new form was not given in the Report, because it is not always quite clear what exactly has been done to it during the interval since the last Report. I think it will be an advantage, possibly, if the burner was mounted on adjustable screws so that it could be kept vertical. There seems to be a possibility of errors being introduced for that reason and I also think it might be an advantage if the gas inlet was provided with some simple form of filter. These are details and, of course, one does not want to complicate the design more than necessary, or to make the thing more expensive than necessary. Finally, I would like to suggest, in regard to periodic calibrations of this burner, the use of some standard gas mixture which could be made up very accurately and be used to check from time to time the calibrations and would, perhaps, avoid any necessity for returning the instrument to the makers.

Mr. F. O. HAWES (Tottenham): At present we are working with a master test burner at Watson House, but an aeration test burner is not like a standard yard which can be built into a wall, and it would be very unfortunate if Mr. Masterman came along one day and said "I am awfully sorry, but some silly person has pushed the master burner off the bench." [Laughter.] Therefore, I think it should be possible for the individual undertakings to calibrate the burner for themselves, and for the ultimate standard we should have some mixtures of pure gases made to standardize two or three points on the test burner scale, so that if any accident should happen we should have some definite reference rather than depending on a purely empirical standard.

Correlating Performance.

It might appear, at first glance, that the 42nd Report does not show a very marked advance over that of last year in our knowledge of combustion characteristics. In point of fact, however, a great deal of work has been done in making sure that the proposed instrument by which measurements are to be taken is not itself liable to changes which might invalidate conclusions drawn from its readings. The Committee is now in a position to commence the more practical programme of attempting to correlate the performance of appliances with the aeration test burner readings of the gases supplied to them.

There still remains to my mind one very disturbing factor. It is pointed out in the Report that the A.T.B. scale is purely arbitrary and the calibration of different instruments must be referred finally to a master burner. This is hardly satisfactory, since accidents are not unknown, and should the master burner be damaged there is no absolute datum to which reference can be made. I have been attempting to devise some standard of measurement by using mixtures of pure gases. A mixture of 25% methane, 40% hydrogen, and

35% carbon monoxide has a calorific value of 488 B.Th.U. per cu.ft. and a specific gravity of 0·507.

These values bring it comfortably into the middle of the aeration test burner scale and the mixture should give the same standard reading on all instruments. Other points on the scale could be fixed by different standard mixtures of these three gases. The gases are not difficult to prepare in the laboratory and only a small amount is required for a check test. I have not yet been able to decide to what extent the purity of the constituent gases will affect the reading, but I submit that such a standard is not impossible of attainment and is highly desirable.

Standardizing the Number.

Mr. C. A. MASTERMAN (Gas Light and Coke Company): The Sub-Committee and Mr. Wood have had in mind maintaining a standard with pure gases and, of course, anybody who is using an aeration test burner at their works can calibrate with a pure gas and determine what the number of that pure gas is, and thus calibrate as and when they think proper. Reference is made in the Report to modifications in the instrument which are fairly well forward now; but they carry with them just this complication, that whereas we have become accustomed to numerical readings on the old instrument, these will not normally be the same on the new type of instrument, and the time will come when the question of standardizing the number will become more and more important. Otherwise, if more modifications are introduced one can see the necessity for a conversion from one set of numbers to those obtained on the instrument before that, and then to the instrument before that, and you will have a rather ludicrous situation growing up. We can never hope to get a number embracing all the aspects of combustion characteristics, including calorific value, but we may be clearer about things next year when Mr. Wood has been able to cover a little more of the other side, by varying the calorific values and so on.

Finally, I would like to add to what Mr. Wood refers to as the importance of development work with the new burner which is being carried on by Mr. Wood and his colleagues. I do not know if this is the appropriate moment to say that the Governor and Directors of the Gas Light and Coke Company emphasize that they want any improvements which may be effected at Watson House not to remain the property solely of the Gas Light and Coke Company, but would be pleased that they should become the property of The Institution of Gas Engineers.

Difficulty of Using Gas Mixtures.

Mr. L. T. MINCHIN (Gas Light and Coke Company): I was very pleased to hear Mr. Hawes refer to the question of the calibration of this burner because I am the custodian of the burner. Personally, I feel sure that the situation which Mr. Hawes mentioned is not quite so bad as it might seem because there are two standard burners in existence, one of which is with Messrs. Alexander Wright & Co. and the other with the Gas Light and Coke Company, and the two are checked together from time to time, so that if any harm should come to one there is always the other to fall back upon. Actually we have a method of calibrating the standard burner, not as Mr. Hawes suggested by using a mixture of gases or a single pure gas, because that method has great difficulties. If you take a pure gas you cannot find one which happens to come on the range which you need for checking commercial gas. Hydrogen is at the bottom of the scale and methane is miles off the top so that you cannot use any pure gas. At the same time, using a mixture of gases is rather a difficult thing, because it is very difficult to get a really accurate mixture of pure gases. At all events it is a thing which would take a month to do to get the necessary accuracy. What we do is to employ a gas of known specific gravity—say, of 0·45 or very near it—and correct back for the very small divergence, and then measure the air/gas ratio of the burner. The amount of air which is drawn in with a given shutter opening, one of the three points on the scale is taken, and a gas of known specific gravity is employed. By that means we check up the air entraining powers of the burner at regular intervals and make sure that the world standard does not change appreciably. Nevertheless, it is very desirable that a still better method should be introduced, and it will certainly be much more satisfactory when we have a better method of air shutter such as that envisaged in the new type of burner. This is less likely to change slowly than the present type, which has a number of defects we are gradually learning about after several years' experience but which were not so apparent, unfortunately, when the burner was first designed.

Mr. A. FORSHAW (R. & A. Main, Ltd.): With reference to the question of the orifice shape and thickness through which the orifice is punched, Professor Newitt indicated that you get waves in the burner. A thin piece of metal with an orifice punched in it gives an unfortunate shape jet which goes with the vena contractor, and that, of course, must have an influence on the amount of air which is entrained. Personally, I have been carrying out some experiments, not with a view to improving the instrument we are now discussing, but with a view to getting the extreme amount of air entrained by a given jet which it is possible to get. It is, of course, very difficult to reproduce an orifice which will give you an invariable result when it is used with a particular gas. We have been trying orifices which have a converging cone followed by a diverging cone, and there are some very interesting results. Unfortunately, I have not brought any of them with me, but we did find that one particular form of jet gave us the extreme of injection.

There is one point upon which I would like to congratulate all those concerned with this work, and that is the extreme accuracy at which they have been working in getting this A.T.B. number, and, of course, it is all to the good; but speaking as one on the staff of a gas appliance manufacturer, I am bound to say that although we hear of this great accuracy in the A.T.B. number, we are given a limit in the works to which we must keep of something between 60 and 90 A.T.B. number in the burners we must reproduce for the public, and I think that is one of those things which gives us to think rather.

Essential Preliminary to Changes.

Mr. G. C. HOLLIDAY (Gas Light and Coke Company): This work on the Aeration Test Burner and gas quality is an essential preliminary to changes which will probably be as important to the Gas Industry as standardization of frequency in the Electrical Industry. Working to narrower limits may restrict flexibility at some manufacturing stations, but against this must be balanced the savings in maintenance and adjustment of appliances and the better and more constant standard of service now demanded by the consumer.

It is the next stage of Mr. Wood's work—*i.e.*, the relationship between Aeration Test Burner Number and performance of appliances which will show us more precisely the magnitude of the effects of changes in gas quality. That these effects exist is easily demonstrated, but their exact relationship to combustion, efficiency, and so on will require a great deal more painstaking and detailed work of which the present Report is such an excellent example.

From the appliance manufacturers' point of view, gas quality is as important as calorific value. If every undertaking were to make the same standard calorific value gas tomorrow, the appliance manufacturers might still have to provide different adjustments for different gas qualities. That is why in any national scheme for standardizing calorific values the problem of gas quality must be taken into account.

Mr. Wood mentions the new and more robust type of Aeration Test Burner in which the aeration is controlled by a slot instead of a rotating disc. Preliminary tests of this burner at Watson House have been very promising. It appears in every way to be preferable to the old type, it is easier to reproduce, to calibrate, to clean and to check, and in addition it covers a wider range of gas qualities than the earlier type. The aeration curve, however, is somewhat different so that similar readings on the two burners will represent different gas qualities. If Mr. Wood confirms the superiority of the new burner I should like to suggest that the new scale should be adopted as standard for measuring gas quality rather than convert the readings to those of an instrument which was admittedly experimental and which will probably become obsolete.

Mr. WOOD was asked to reply to the Discussion in writing.

43rd Report of the Joint Research Committee of the Institution and Leeds University

The Investigation of the Use of Oxygen and High Pressure in Gasification. Part III.—Synthesis of Gaseous Hydrocarbons at High Pressure

Research Chemist: F. J. Dent, B.Sc., Ph.D. *Research Assistants*: W. H. Blackburn, M.Sc., Ph.D.; H. C. Millett, B.Sc., Ph.D.

[ABSTRACT]

Communication No. 190

The experiments described in the 41st Report of the Joint Research Committee showed how gaseous hydrocarbons had been produced in quantity from non-caking coals and low-temperature cokes by heating them in a stream of hydrogen under pressure from about 600° to 800° C. In a typical experiment at 50 atmospheres, 62·5 per cent. of the fuel was gasified in the hydrogen and 275 therms were obtained in gaseous hydrocarbons per ton of fuel. The outgoing gas averaged more than 500 B.Th.U. per cu.ft. throughout the hydrogen treatment and exceeded 700 B.Th.U. per cu.ft. at one stage.

Using the same apparatus as before, it has now been found that a considerably more extensive gasification can be obtained by hydrogenating up to temperatures above 800° C. At higher temperatures, the decrease of hydrocarbon formation with continued passage of hydrogen was much less pronounced and the treatment was usefully continued for a longer time. The best results were obtained by hydrogenating up to 900-950° C.

Coals, after a preliminary carbonization at 450-500° C. to destroy their caking properties, gave yields between 500 and 600 therms per ton in gaseous hydrocarbons while the calorific value of the outgoing gases remained above 500 B.Th.U. per cu.ft. From 70 to 85 per cent. of the carbon in the coals was gasified and it is remarkable how the rate of hydrocarbon production was maintained towards the end of the experiments when only small amounts of material remained in the reaction tube.

High yields of gaseous hydrocarbons were also obtained when using coals directly without a preliminary heating. The fusion of the coal into one piece during the treatment did not appreciably interfere with hydrogenation in the small reaction tube used, although ill effects due to by-passing might have been expected. The percentage of residue was even less than with the coals which had been rendered non-caking.

Experiments have also been made on cokes prepared at temperatures as high as 800° C. With these, the advantage of increasing the final temperature of hydrogenation to 900° C. was especially pronounced. When hydrogenated up to 800° C., a temperature to which they had already been exposed during preparation, they gave a low yield of gaseous hydrocarbons but, with a final temperature of 900° C., the yield was not greatly inferior to that from coals and low-temperature cokes. Thus, with a typical 800° C. coke, hydrogenation up to 800° C. gave 140 therms in gaseous hydrocarbons per ton, whereas hydrogenation up to 900° C. gave 520 therms.

The results indicate that in a continuous plant, operated with replenishment of the fuel bed, coals and cokes prepared at temperatures up to 800° C. could be practically completely gasified in hydrogen at 50 atmospheres, if the temperature of the fuel bed were maintained around 900° C. and if, with coals, caking properties did not give rise to difficulties on the larger scale of operation.

It was found that the rate of gasification of fuels in hydrogen was accelerated by the presence of alkalies. So far, experiments have been made with sodium, potassium and barium carbonates, with particular attention to sodium carbonate as one of the cheapest alkalies available. The influence of the alkalies was most marked when hydrogenating coke at relatively low temperatures. As an example, a coke prepared from an intimate mixture of coal and 3 per cent. by weight of sodium carbonate gave 463 therms per ton in gaseous hydrocarbons when hydrogenated at 800° C. In the absence of alkali, only 140 therms were obtained.

When hydrogenating up to 900° C., since all the fuels tested were readily converted into hydrocarbons without any addition, the influence of alkalies was less marked than at 800° C. There was still, however, an appreciable acceleration of hydrocarbon formation towards the end of hydrogenation and, as a consequence, gasification to completion was facilitated. It was also found that the addition of sodium carbonate increased the ability of coke to withstand heat treatment without losing its activity towards hydrogen.

In view of possible mechanical difficulties which might arise on the large scale if the fuel cakes during gasification, it is noteworthy that the admixture of alkalies considerably reduced the caking of coals. Indeed, except in the case of strongly-caking coals, fusion and caking, even in hydrogen under pressure, were completely prevented by the addition of 3 per cent. of sodium carbonate.

There is evidence that the percentage of methane in the gas produced in some of the experiments on coke reached the maximum permitted by equilibrium. The highest percentages of methane obtained at 50 atmospheres were 57·3 at 800° C., 43·0 at 900° C., and 36·3 at 950° C. If these are equilibrium values, it can be calculated that, at 10 atmospheres, gas with a calorific value of 500 B.Th.U. per cu.ft. cannot be made above 825° C., at 25 atmospheres above 925° C., or at 50 atmospheres above 1,035° C. Moreover, with a pressure of 50 atmospheres, gas of 600 B.Th.U. per cu.ft. cannot be prepared above 915° C., gas of 700 B.Th.U. per cu.ft. above 810° C., or gas of 800 B.Th.U. per cu.ft. above 700° C. Obtaining gas of the highest calorific value possible at a given temperature depends upon the fuel having adequate reactivity at that temperature. Thus, from the figures given it follows that, when attempting to make gas of 500 B.Th.U. per cu.ft., if the coke is insufficiently reactive at 825° C., a higher reactivity can be obtained by raising the temperature to 925° C. but then the lower limit of pressure increases from 10 to 25 atmospheres. A still greater reactivity can be obtained at 1,035° C. but the pressure must then be above 50 atmospheres. These data apply to the use of pure hydrogen for hydrogenation when the gas at equilibrium consists solely of methane and uncombined hydrogen. Further data are given in the Report for circumstances in which the "hydrogen" used for hydrogenation contains appreciable quantities of carbon monoxide and smaller quantities of carbon dioxide and nitrogen.

A series of experiments has been made on the hydrogenation of coal using various rates of hydrogen supply at various rates of heating to the final temperature. The results can be best understood by making a broad distinction between two periods in the hydrogenation, viz., an initial period in which the coal was undergoing thermal decomposition while being raised in temperature and a final period in which the solid residue approached a condition of thermal stability at a steady temperature. During the final period, the rate of formation of hydrocarbons was limited and depended mainly upon what final temperature was maintained. During the initial period, however, it appeared that thermal instability conferred a high reactivity upon the coal and rapid rates of heating led to high rates of hydrocarbon production when using an adequate supply of hydrogen. As an example, heating at 12° C. per min. and supplying hydrogen equivalent to 58,000 cu.ft. per hr. per ton gave the first 200 therms of hydrocarbons per ton at an average rate of 220 therms per hr., corresponding on dilution to gas of 500 B.Th.U. per cu.ft. with a rate of gas production of 415 therms per hr. per ton. This output secured from the laboratory apparatus can-

not be compared directly with that obtained by normal large-scale carbonization, namely, approximately 7 therms per hr. per ton, but the difference between the two is so wide as to be significant. It should be noted that the first 200 therms in hydrocarbons per ton are ample for enrichment purposes in a process in which the residue from hydrogenation is used for hydrogen production.

Previous workers have found that coals contain aromatic constituents and that, on heating, the benzenoid structure becomes more pronounced in the solid residue. Thus, it follows that the complete gasification of coals in hydrogen to simple hydrocarbons such as methane involves the breaking down of six-membered carbon rings. Such break-down was demonstrated more directly by making experiments at 50 atmospheres on the hydrogenation of aromatic compounds of known composition, such as benzene, anthracene, and xylene. It was found that the conversion of benzene to gaseous hydrocarbons became appreciable at 750° C. The conversion was rapid at 850° C. when approximately two-thirds of the benzene was decomposed to methane in a time of about 1 min. Anthracene, with linked carbon rings, was more readily decomposed than benzene. Approximately one-third of the anthracene was converted to gaseous hydrocarbons at 650° C., and more than three-quarters of it at 800° C., again in a time of 1 min. With xylene there was an appreciable formation of methane as low as 550-600° C., presumably due to the early hydrogenation of the side chains. It appeared that the hydrogenation of the side chains was complete at 700° C., and that hydrogenation of the nucleus then began as with benzene.

In the 41st Report it was shown that when fuels were heated in hydrogen under pressure, the rate at which gaseous hydrocarbons were produced passed through two maxima, one at 500-550° C. and the other at 750-800° C. The experiments just mentioned suggest that the second maximum represented the hydrogenation of the basic six-membered carbon rings, the first being accounted for by the hydrogenation of side chains, chain compounds, etc.

Preliminary Experiments.

Some preliminary experiments have been made on a larger apparatus with a retort 4 in. in internal diameter, holding approximately 1 kg. of fuel over 10 in. of its length. The size of the apparatus was so chosen that the liquid products from coal would be sufficient in quantity for measurement and some examination, that heat liberated or absorbed during the reactions would be perceptible, and that effects caused by any caking of the charge could develop. The retort was supported vertically and hydrogenation started by passing hydrogen, preheated to 800-850° C., downwards through the charge.

When hydrogenating coals and low-temperature cokes at 50 atmospheres in this larger apparatus it was found that the reactions began when the upper layers of the charge reached 550-700° C. As expected, the reactions proved to be exothermic and the temperature of the reaction zone rose to 900-1,000° C. The rate of temperature rise was rapid, about 100° per min. The amount of heat evolved by the reactions could not be measured, but it was plain that it would be sufficient to maintain the reaction temperature when operating on a large scale. Usually, there was a general fall in temperature after the reaction zone had travelled through the charge, and then the reactions ceased suddenly. It appeared that, once the high reactivity induced by a rising temperature had passed, the rate of reaction was insufficient to maintain the temperature because of the excessive loss of heat from the comparatively small retort. In consequence, only the initial rapid evolution of hydrocarbons was obtained, the yields varying from 100 to 150 therms per ton. The fall in temperature and the cessation of the reactions did not occur, however, when the fuel contained a small percentage of sodium carbonate and it was then possible to continue gasification almost to completion.

With coals, approximately 15 gal. of light tar were produced per ton, and there was a high yield of ammonia, *e.g.*, equivalent to 100 lb. of ammonium sulphate per ton.

Caking did not appear to interfere with hydrogenation any more than it did in the small reaction tube. This observation may prove to be of importance. If the same behaviour were observed on the commercial scale, it would mean that, in producing gaseous hydrocarbons by hydrogenation, it would be unnecessary to take special steps to destroy the caking properties of coal.

Mr. H. C. Smith (Chairman of the Joint Research Committee), presented the Report.

Professor J. W. Cobb (late Livesey Professor) also introduced the Report, and Dr. Dent briefly discussed its contents.

Discussion

Professor D. T. A. Townend (Livesey Professor, University of Leeds): I think we shall all agree that the 43rd Report of the Joint Research Committee is a document which maintains our interest at a high level in the subject of the gasification of coal. The field covered has been surveyed experimentally with commendable expedition.

It would be correct to say, I believe, that when this programme of work was first undertaken a main interest lay in finding out whether useful yields of methane could be obtained by gasification of the coals available in this country with the object of obtaining a gas of high calorific value. Now it is known that methane can be produced in large quantities by a process essentially of hydrogenation, and the flexibility of high pressure operation is such that, with suitable variation in procedure, a coal may be completely gasified to meet any requirement in regard to calorific value.

Perhaps the most impressive feature of the work is the remarkable rate of gasification which the experiments seem to indicate as quite normal to this method of working.

The outstanding future problems so far as gas making is concerned would seem to be of a mechanical type, in regard to such matters as throughput, and the coking properties of the coals concerned, and it may be hoped that the work will be still further developed along those lines, for it could hardly fail to yield information of great value.

Conserving Coking Coals.

From a national standpoint it would seem desirable that any method which provides a means of utilizing "smokelessly" a wide range of fuels should be encouraged, with the object of conserving our caking coals. Taking a broad view, it would seem that both carbonization and gasification methods of gas production will always be complementary, and among other things the new gasification process, if successfully developed, should give greater control of coke supplies than had been possible hitherto.

One of the most interesting features of Dr. Dent's work is the observation that there are two distinct phases of methane production—the one at lower temperatures, and presumably concerned with the early product of thermal decomposition, and the other at higher temperatures, concerned almost entirely with the carbonaceous residue. So far the main object of the work has been to produce gas, the hydrogenation being very drastic and accompanied by considerable heat evolution, without doubt promoting thermal dissociations. It would seem well worth while to study under conditions more controlled by heat exchange the lower temperature hydrogenation, in the hope of isolating valuable and less completely hydrogenated products. The main gasification might then well be effected by hydrogenation of the residues at higher temperatures, and in this connexion the further study of the influences affecting their reactivity is of undoubted importance. Such a process would also obviate possible difficulties due to caking; and this is an aspect of the matter which, I am aware, has already received consideration. The aromatic compounds, as reported, were also submitted to the same drastic treatment, and it might well be worth while studying their hydrogenations in much more detail under rigidly controlled conditions. In the long run it may not be the most rapid gasification of a material which will yield economically the most valuable products.

It is suggested in Section III (5) of the report that the difference between the equilibria in the system carbon, hydrogen, and methane as calculated and found experimentally may be due to error in the heat of reaction employed in the calculation. It seems to me that the question of a compressibility correction may possibly also be of importance.

I hope that it will not be out of place for me to tell you that I am now happily installed in Leeds and enjoying my new work. I should like also to take this opportunity of thanking the many of you for the good wishes I have receive.

Light on the Theoretical Side.

Dr. J. G. KING (Fuel Research Station): I have followed with the very greatest interest Dr. Dent's researches upon the treatment of coal with hydrogen. These are of peculiar interest to the chemist in that they shed light on the theoretical side of hydrogen attack. After the removal of volatile matter under conditions which avoid cracking and favour a high degree of conversion of carbon to gas and tar we can visualize the gradual formation of graphite crystallites, the removal from these of side chains as methane, followed by the gradual disruption of their structure again to yield methane. I imagine, however, that in the process at present visualized the attack will be stopped with the removal of the side chains.

The ultimate object of Dr. Dent"s' researches is, however, a practical process of gas manufacture, and with this 3rd Paper he now seems to have taken his experimental work to such a stage that the time is ripe for increasing the scale of his experiments. A full-scale plant obviously cannot be developed until the process has been operated on an intermediate scale in which the difficulties inherent in the process can be explored. The first step towards this has been made by Dr. Dent in his work with a 4 in. tube on the hydrogenation of coal.

It is interesting to consider how the results he has obtained will influence the next stage. In his first reaction tube of 1 in. diameter, the effect of the heat of reaction was imperceptible. In the 4 in. tube, where the heat losses were relatively much less, the exothermicity of the reaction became apparent. Dr. Dent has not been able to measure the heat of reaction yet, but he does postulate that it will be sufficient in full-scale operation to maintain the reaction temperature once the reaction is started (Figure 23A). This is most important, since it would obviously be undesirable to supply heat internally.

From some preliminary calculations I have made it appears that the complete hydrogenation of coal to methane is endothermic, while that of coke is strongly exothermic, and at some stage between the two the heat of reaction is negligible. It follows that if during hydrogenation a rise of temperature occurs, volatile matter will be evolved, the reaction will become more exothermic and a further rise in temperature will result. It is of the greatest importance to consider how this reaction temperature is to be controlled.

Dr. Dent's very interesting equilibrium data suggest that it would be undesirable greatly to exceed 1,000° C. when working at 50 atmospheres pressure. In the experiments in the larger apparatus a reaction temperature approaching 1,000° C. was readily obtained with a preheating temperature for the hydrogen of 800-850° C. In much larger reaction chambers it occurs to me that the temperature may be very much more difficult to control, and it would be interesting to hear whether Dr. Dent had any such preliminary difficulties in his larger apparatus. My experience in full-scale hydrogenation suggests that exothermic reactions on a large scale may be fairly readily controlled (by regulating the preheating temperature and so on) provided that steady conditions can be maintained when they are once achieved. This requirement can, of course, only be realized in a continuous process. Unhappily, I have no suggestions to offer for the conversion of Dr. Dent's process into a continuous process, but I should like to have Dr. Dent's views regarding a continuous process. The latter has, of course, many other virtues—not least among which is the fact that it reduces the making and breaking of high-pressure joints to a minimum.

South Metropolitan Experiments.

Mr. J. E. DAVIS (South Metropolitan Gas Company): The experiments on the hydrogenation of pure hydrocarbons give rise to a number of suggestions that may be fruitful in helping us to understand better the constitution of coal and the nature of the reactions which accompany its decomposition by heat. There is probably enough here to keep research workers employed for some years to come on the theoretical aspect alone.

It would, however, be most unfortunate if interest in the theoretical aspect were to hinder efforts to make some practical application of these discoveries. During the year one most important step forward has been made, and it is just possible that the significance of this might be overlooked. From working in a tube having a diameter of only ½ in. the size of the apparatus has been increased until it is now 4 in. in diameter, that is, a sixfold increase. Another similar increase would bring us to a plant of commercial size. The experiments made so far with a larger tube confirm and amplify those obtained with the smaller vessel, and I may add that in the Central Laboratory of the South Metropolitan Gas Company we, too, have been experimenting with a vessel 4 in. in diameter, and again the experiments that we have made, in so far as they have covered the same ground, give results coinciding closely with those obtained at Leeds.

The experiments have revealed several facts of considerable potential importance. We can obtain substantially complete conversion to methane under widely varying conditions of raw material, temperature, and pressure. If we are prepared to be reasonable and to limit our demands for methane to such as will suffice for the production of a gas having a calorific value of 500 B.Th.U. per cu.ft. we can obtain this quantity of methane at a rate substantially in excess of that shown by any existing gas producing process operating in a vessel of the same size.

Quite surprisingly the use of a coking coal does not appear to give rise to the troubles that we had expected. The yield of tar can be controlled by choice of the conditions within wide limits.

A high proportion of the nitrogen in coal is converted to ammonia, and this should be obtainable at a concentration in the liquor which would make its recovery quite a different commercial proposition from the treatment of ordinary gas liquor. The difficulties which are due to the presence in ordinary coal gas of hydrogen cyanide and naphthalene simply do not arise.

Sulphur behaves in a most interesting manner. At the South Metropolitan Gas Company we have found that an unusually high proportion of the sulphur in the coal is eliminated in the gas, leaving a coke of particularly low sulphur content. Incidentally, this coke displays exceptionally high reactivity and adsorptive properties. Of most significance is the fact that substantially all of the sulphur in the gas is present in the form of hydrogen sulphide, and after removal of this impurity there remains considerably less than 1 gr. of organic sulphur compounds per 100 cu.ft. of gas.

Some of these results are not wholly unexpected, but we had hardly dared to hope that they would be realized so fully. Of course, all these observations have been made with coal charges weighing, at the most, 1 kg. and with supplies of hydrogen from external sources, and we all know of the very many processes which have looked attractive in the laboratory but could never prove feasible commercially. But, with what is known already of the possibilities of gasifying a non-coking carbonaceous fuel in steam and oxygen under pressure it will be most extraordinarily bad luck if we are unable to obtain with commercial success at least some of the most attractive results which this experimental work promises.

Laboratory Success.

Mr. T. F. E. RHEAD (Birmingham): We have now seen the completion of three years' work on the processing of coal on new lines, and one cannot but be struck with the astonishing success met with in the laboratory. Much of this must be attributed to the tireless and fearless manner in which Dr. Dent and his assistants have prosecuted their work. Tribute must also be paid to the steel makers who have produced a metal capable of withstanding 50 atmospheres at over 950° C. I notice that with the larger apparatus internal heating has been resorted to, and temperatures as high as 1,000° C. were reached.

The fact that the methane synthesis takes place more readily during the period of coal distillation, when everything is nascent, is not surprising, but the speed and ease with which it does this has surpassed all expectations. Even the coke made at temperatures over 800° C. readily methanizes at 900° C., and such coke is much less difficult if previously mixed with a catalyst such as sodium carbonate.

Working at lower pressures may become possible as the effect of catalysts is explored, and one presumes that such work is in the programme.

There must be many like the speaker who feel that, although fundamental research must continue unabated, the time has come for a larger experimental unit being tried out, and though the cost will run into many thousands of pounds,

this will doubtless be more than repaid in the knowledge gained. Such larger scale work will almost certainly give rise to problems requiring further elucidation, as factors which were either non-existent or of little significance in a laboratory unit often assume major importance in a large one. Quite obviously high pressure and catalysis technique has such alluring attractions that it will withstand the many disappointments which are bound to come before commercial success is achieved. We cannot afford to let others get into the field before us.

Necessity for Caution.

Professor A. C. G. EGERTON, F.R.S. (Professor of Chemical Technology, Imperial College of Science and Technology): I feel very much in the same way as others who have referred to the future possibilities of this work. At the same time, it is necessary to go forward with caution, to take every care that each step is thoroughly worked out from the experimental point of view. In methane there are great possibilities, I think; it is a beautifully stable molecule, with wonderful combustion characteristics, and I feel sure that insufficient attention has been paid to it as a future fuel.

One point which we have to consider very carefully is that raised by Dr. King as to the utilization of this work, whether in the direction of producing a two-stage or a single-stage process; and we must always remember that we are making hydrogen in the first place, and it is not easy to make hydrogen very cheaply. We must bear in mind the very useful observations which Dr. Dent has made on the early stages of the process, that in the breaking down of the benzenoid structure of the coal the hydrogen is attacking the coal very rapidly; it seems quite possible, therefore, that a two-stage process might prove to be the most effective, provided the engineers can overcome the difficulties referred to by Dr. King.

Another valuable point mentioned by Mr. Davis was that of the ease of the removal of sulphur by all processes of hydrogenation.

A point raised by Professor Cobb, and which interested me very much, was the importance of studying the effect of steam on coal. In my view, not nearly enough work has been done on the effect of steam on pure carbon, because one has only to study the work of Lambert and Hinshelwood on the oxidation of carbon to realize how very little we know concerning what is going on even in these simple reactions. It is all very well to say that carbon + water will give hydrogen and carbon monoxide. But how does it take place? There is no doubt that the water will not split into $H_2 + O$, but into hydrogen + hydroxyl, and the hydroxyl then attacks the carbon. What happens then to the hydrogen atom that is formed? It is in that particular region where the interesting effect of the alkalis on the coal is going on, because they have an extraordinary effect in breaking the chains of hydrogen atoms and causing hydrogen to combine at the surface of an alkali. Why, we do not know. So that there is a very big field for research which is certain to tell us more about what we should do.

Then Professor Townend referred to the importance of finding out whether other hydrocarbons could be formed. Already in the oil industry the effect of hydrocarbons in the presence of carbon monoxide and hydrogen under pressure is being investigated, with successful results.

1st Report of the Gas Works Safety Rules Committee

[ABSTRACT]

Communication No. 191

The members of the Gas Works Safety Rules Committee are:

F. M. Birks, O.B.E., M.I.Mech.E. (*Chairman*); H. E. Bloor, B.Sc., B.Eng.; J. R. Bradshaw, B.Sc; J. M. Campbell, J.P.; Thomas Carmichael, M.Inst.C.E., M.I.Mech.E.; J. E. Davis; Thomas Hardie, M.Inst.C.E.; H. Hollings, D.Sc.; James Jamieson; J. W. Napier, M.B.E.; G. C. Pearson, M.Inst.C.E.; T. F. E. Rhead, M.Sc.; Charles S. Shapley, M.I.Mech.E.; H. C. Smith, M.Inst.C.E.; E. G. Stewart; E. B. Tomlinson, M.Inst.C.E.; F. H. Vince, M.I.Mech.E.; the President, the two Vice-Presidents, and the Honorary Secretary of the Institution (*ex-officio*).

Co-opted: Leslie F. Stemp, B.A.

I INTRODUCTION

The Gas Works Safety Rules Committee was appointed by the Council of The Institution of Gas Engineers on 12th January, 1937, its Terms of Reference being as follows:

> "It was resolved to appoint a Gas Works Safety Rules Committee to deal with all matters relating to Rules for the Safe Operation of Gas Works and to elect thereto the members of the Gasholder Committee and of the Purifiers Committee."

II RECOMMENDATIONS

(*a*) *Voluntary Rules for the Safe Operation of Purifiers*

Voluntary Rules for the Safe Operation of Purifiers, which have been drawn up by the Committee and its predecessors, are printed in an Appendix to this Report. These Rules have been submitted to the Factory Department of the Home Office, whose friendly criticism was very helpful in the framing of them and was much appreciated by the Committee. Although it is recognized that the Rules may not be applicable in their entirety to all Gas Undertakings, the Committee urges that they be adopted as quickly as possible by every Undertaking to the full extent that they are applicable.

(*b*) *Corrosion of Gasholder Sheeting*

Reports have been made to the Committee of external corrosion of sheeting below the water line in the cups of water-sealed gasholders.

The Committee desires to draw attention to such external corrosion, which may be obviated by keeping the cups properly filled with clean water.

With care, corrosion at the wind and water line should be small but corrosion does occur at the bottom of cups which is probably caused chiefly by the slurry which collects at the bottom of the cups. The Committee, therefore, recommends that the slurry should be removed and the cups cleaned each year, when opportunity may also be taken to paint, if required.

(*c*) *Anti-Freezers Causing Siphoning of Sealing Water from Cups of Water-Sealed Gasholders*

From time to time accidents have been reported through faulty operation of anti-freezing gear, resulting in the siphoning of sealing water from cups of water-sealed gasholders. Experience has shown that this siphoning of water from the cups of water-sealed holders is due to a vacuum being formed in the steam or hot water supply pipe when the steam or hot water has been shut off at ground level. The injector or steam jet being submerged in the cup, the water is sucked back and should the drain cocks be open at the foot of the stand supply pipe the water will be siphoned out to the depth of the injector or jet in the cup.

These injectors should not be placed too deeply in the cup as not only is better circulation of water obtained near the surface but an additional safeguard is given against sucking back should the anti-vacuum valve fail.

As an additional precaution against siphoning, a non-return valve may also be fitted to all the anti-freezing apparatus.

(*d*) *Respirators for Carbon Monoxide*

The Committee desires to draw attention to the fact that the Government general service, civilian duty, and civilian

war gas respirators do not give protection against carbon monoxide, and that if such respirators are worn in the presence of town gas they may actually be a source of danger, since the warning smell of town gas is removed by the carbon filter of these respirators. The Committee, therefore, recommends that emergency A.R.P. repair gangs should be provided with respirators specially adapted to deal with war gases simultaneously with coal gas, or alternatively be trained in the use of oxygen breathing apparatus.

(e) Testing of Gas Works Valves

The Committee desires to draw attention to the importance of operating all gas works valves at regular intervals to ensure that they are in working order and it therefore recommends that a regular scheme of operation of all gas works valves should be one of the safety precautions in operation at all Gas Works.

III FACTORIES ACT, 1937

(a) Exemptions

The Committee has considered the various provisions of the Factories Act, 1937, particularly applicable to Gas Undertakings and joint action has been taken by The Institution of Gas Engineers and the National Gas Council in making application for collective exemption from Sections 27 (*b*) (water-sealed and piston-type gasholders) and 28 (4) for water-sealed gasholders.

(b) Gasholder Record Sheets

It is gratifying to record that 207 Gas Undertakings (representing 65·6 per cent. of gas made in Great Britain and Ireland) have adopted the Institution's gasholder record sheets, and that, including sales to contractors and consulting engineers, 3,840 sets of sheets for water-sealed and 400 sets for waterless gasholders have been supplied.

In this connexion and in view of a number of enquiries that have been received, the Committee desires to point out that it is necessary for all Gas Undertakings to comply with Section 33 (2) of the Factories Act, 1937, and to keep records of inspection of water-sealed gasholders as prescribed by the Home Office in Statutory Rules and Orders, 1938, No. 598.

Arrangements have now been made, after consultation with the Factory Department, to issue for the use of Undertakings a record sheet complying with the above-mentioned Order. This record sheet will not replace the gasholder record sheets already issued by The Institution of Gas Engineers, which contain much information necessary to the management of a Gas Undertaking but not contained in the record prescribed by the Home Office.

IV AIR RAID PRECAUTIONS

Air Raid Precautions Memorandum No. C1, 2nd Edition, Air Raid Precautions for Gas Undertakings, was published in July, 1938, the Committee having collaborated with the Air Raid Precautions Department of the Home Office in the revision of the technical sections.

APPENDIX

VOLUNTARY RULES FOR THE SAFE OPERATION OF PURIFIERS

Issued by The Institution of Gas Engineers after consultation with the Factory Department

These Voluntary Rules are for general application. Each rule may not apply to every purifier installation, and additional rules may be necessary to suit individual purifier installations.

All plant and accessories must be regularly inspected and kept in order, as provided for in the normal routine of plant examination and maintenance.

"Engineer" is intended to include any qualified person to whom the duties in question may have been entrusted.

"Authorized person" is a man experienced in the use of machinery used in connexion with, and in the care and maintenance of, purifiers and purifier houses.

A. General Safety Precautions

1. Notices shall be prominently displayed to the effect that
   (*a*) All naked lights and smoking shall be strictly forbidden in and in connexion with purifiers and purifier houses.
   (*b*) No matches, lighters or unauthorized portable lamps shall be used by persons working in and in connexion with purifiers or purifier houses.
2. Purifier houses shall be adequately ventilated. All walls shall be provided with openings and roofs shall be ventilated. In the case of a floor over purifiers, permanent openings or ventilating shafts shall be provided in the floor, unless adequate ventilation exists immediately beneath the floor.
3. Fire fighting appliances shall be installed in commanding positions.
4. Spark arresters should be fitted and maintained in efficient condition in the smoke boxes of yard locomotives, travelling cranes and other plant containing fire, which shall not be allowed near purifiers whilst the operation of blowing off, or raising the covers, is in progress.
5. Provision shall be made to prevent water-sealed lutes and water-sealed valves, including their water supply and drain services, from becoming frozen in frosty weather.
6. Water-sealed gas valves should have the water connexion above the water level of the flooded valve. The drain cocks and services should be of wrought iron, steel or malleable iron. Such gas valves should be provided with a visible overflow, which should be maintained and regularly observed to be overflowing when the purifier is open.
7. The temperatures and pressures of all purifiers should be taken at least daily and recorded.
8. A responsible person shall determine the best position in the series for a purifier due to be changed—usually first or last. The main considerations are:
   (*a*) The maximum reduction in temperature in the purifier before opening, and
   (*b*) The maintenance of clean gas at outlet purifiers.
   A purifier should occupy the position decided upon for at least twelve hours before opening.
9. A safety blow pot is desirable in some position between the exhauster outlet and the purifiers, and arranged, when safe pressures are exceeded, to blow off gas through a vertical pipe to a place of safety.
10. Wooden mallets should be used for loosening lid fastenings, etc.
11. Any operation which necessitates entering unventilated spaces shall be carried out under the direct supervision of an authorized person, by men wearing suitable breathing apparatus and a belt to which a rope is attached with its free end held by a person outside. Reviving apparatus shall be available.
12. During the operations of shutting off, opening and putting to work purifier boxes, an authorized person shall always be present and shall supervise each stage of the work.

B. Shutting Off, Testing for Leakage and Removal of Covers

1. Before commencing these operations all reasonable precautions shall be taken to eliminate any source of ignition.
2. The purifier shall be isolated by shutting all its valves and then opening the air valve slowly to allow a gradual reduction of pressure. When the pressure is completely released, the air valve shall be closed and left for sufficient time to prove complete isolation of the purifier by noting the maintenance of

level gauge conditions on a portable gauge fitted to the test cock on the cover. If satisfactory, the air valve shall be re-opened and the cover raised; if pressure is shown by the gauge, steps must be taken to stop the leakage and a further test then made. Where a leak (such as a leaking valve or a cracked division plate) cannot be stopped before the purifier is opened and emptied, the engineer must be informed and take all necessary steps to ensure safety.

C. Emptying and Filling

1. Before the work of emptying a purifier is commenced, the authorized person in charge shall satisfy himself that the vessel is safe for entry and a belt or rope shall be immediately available during the time of emptying.
2. It is recommended that once the emptying of a box has begun the work should be completed without interruption. Should this be impossible, special precautions should be taken.
3. Oxide shall not be allowed to remain in such a position as to interfere with the operation of, or, in the event of spontaneous combustion, to cause damage to gas valves, syphons, fire hydrants and appliances.
4. Oxide freshly discharged from boxes shall be kept under observation.

D. Putting into Commission

1. Rule B.1 shall be applied.
2. On the completion of refilling a box and replacing the lid, the box shall first be "blown" by opening the air valves on the covers and admitting gas. The box shall then be proved tight.
3. Purifiers newly charged with oxide and not required for immediate use, should be left, after "blowing" under gas pressure.

E. Electric Lighting and Power

1. *Electric Lighting.*—The fittings enclosing the lamps should be of flameproof construction (See B.S. Specification No. 229-1929 in relation to Group III gases [Coal gas (towns' gas) and coke oven gas], Mines Department Circulars Nos. 85 and 86 dated 20th May, 1936). The necessary controlling equipment unless situated outside the areas of risk, such as switches, fuse boxes, junction boxes, etc., should also be flameproof to the same standard.
2. *Electric Power.*—Electric power involving the use of equipment which does not incorporate a flameproof enclosure should not be operated when there is any danger of an explosive atmosphere being present.

Note: 1. *Flameproof Enclosure.*—This term denotes enclosures constructed in accordance with the appropriate Specification of the British Standards Institution, and certified in the atmosphere of risk (coal gas) by the Mines Department Testing Station, Buxton.

2. Alternatives to flameproof enclosure, such as segregation, forced ventilation, may be adopted subject to the approval of the Factory Department of the Home Office.

Mr. F. M. Birks, Chairman of the Committee, introduced the Report.

Discussion.

Mr. A. H. Andrews (South Metropolitan Gas Company): There are one or two points to which I should like to make brief reference. I notice in the first place that this is the First Report, but I hope it is only the forerunner of many others, because there are numbers of points concerned in the safety of gas-works which could be covered by the Report but which are not covered in this particular one. Running through the Report generally, I notice the use of the word "voluntary," but that is a word for which I have no use. I think the operations are so important and the risks so involved are so serious that perhaps the matter should have been one in which the average gas engineer should be impressed to adopt a uniform practice. I am referring more particularly to discharging and charging purifiers. The practice of my Company differs somewhat from the draft rules laid down in the Report. I have no objection to any of them, but perhaps the members may like to know that in the case of water sealed purifiers, when we raise the cover we allow air to be drawn in from the bottom of the box and that differs somewhat fundamentally from what is advocated in the Report. In the case of the non-lute boxes, the air under pressure is blown also from the bottom of the box.

The recommendations regarding corrosion of gasholder sheeting are excellently framed and can be generally applied to all undertakings, but there again the practice of the South Metropolitan Gas Company is somewhat different, but only in its elaboration. The main point, in my judgment, in the operation of a gasholder is the constant supervision and examination of the water seals in the cups. In our case we fill these cups every eight hours, and not only are they visually inspected by the man in charge, but a report is recorded in a shift log, and we consider that of great importance. Bound up in that necessity is the likelihood of the anti-freezing apparatus going wrong, and it does go wrong sometimes. The visual inspection of the gasholder we consider of very great importance in the management and running of gasholders. We carry out hourly visual inspections of all the cups, and that is not only advisable but necessary. We not only inspect them, but we give them a coat of boot-topping composition to assist in the preservation of the wind and water line. From the practical point of view also, the cleaning of the cups is vital. At times of the year when painting operations take place it is necessary to be extremely careful to inspect the cups immediately after the holder has been painted. We have found collections of tools and all sorts of pieces of apparatus in the gasholder cups after the painting operations have been completed, and the risk of injury to the gasholder is very great when these hardened steel tools are allowed to remain in the cups. I can sympathize most sincerely with the recommendations of the Committee regarding the anti-freezing apparatus. We have recently in our own Company had an instance of this form of apparatus going wrong, and the result was that the holder dropped a lift, happily without suffering any injury.

Respirators.

Dealing with the question of respirators, the Committee, I notice, are hopeful that a form of respirator will be devised suitable for use in an atmosphere of CO or any of the noxious gases likely to be met with. At the moment I am not aware of such an apparatus for filling such a dual purpose, but if the Committee have one in mind it will be of great interest and benefit to the Gas Industry. The form of apparatus which we use is not one similar to that recommended by the Committee. We find that the most suitable type is a rubber mask which is fitted over the head with a mouthpiece, and attached thereto is a length of armoured air pipe not exceeding 100 ft. in length. That is the maximum which can be conveniently operated by an ordinary workman. This type of mask has the advantage that the man does not suffer from the bugbear of perspiration which always arises when one is enclosed in a mask or helmet.

Now we come to what is, in my judgment, the most important part of the Report, but which receives very little prominence, I mean the recommendations regarding valves. The Committee recommend that valves should be operated, and while I agree that valves should be operated, this operation does not indicate that they are necessarily in good condition. I think the most important part of a gas-works is the safe and efficient testing of the valves, and not only should they be operated at frequent intervals, but at less frequent intervals they should be inspected. Those valves that are in the stream of unpurified gas are most likely to suffer deterioration, and especially the springs, and I can commend to all those engineers who are in charge of large undertakings, and even small undertakings, having a considerable number of valves under their supervision, to introduce a numbering system whereby all valves are numbered and recorded in a register, and the time of their examination and testing is entered therein. That is the standard practice of the South Metropolitan Gas Company, and is one of the most useful things concerning the safety of its work. Speaking of large size

valves, we have a method of dealing with valves from 26 in. up to 48 in. diameter. Before closing the valves, we put on a meter to ascertain the quantity of gas that may be passing these valves, and in one case last summer we found that the amount of gas passing was 9 cu.ft. per hour. I merely mention this to emphasize the importance of the inspection of valves and the advantages that are to be obtained by the kind of attention that is constantly showered on our valves.

Another part of the Report deals with a matter in which I am particularly interested. It recommends that a safety blow-pot should be inserted between the outlet of the exhausters and inlet of the purifiers. That is a most commendable recommendation and one that should be adopted, but as a supplement to that I would also commend to the notice of those in charge of undertakings that it is equally necessary to protect the retort house governors from extremes of pressure or vacuum. That is the more necessary in view of air raid precautions. The apparatus which I would suggest would be a form of safety seal which blew under certain pressure and also lost its seal when the vacuum exceeded certain limits. This measure of safety has been a standard practice in the South Metropolitan Gas Company for many years, and I can commend it to everyone who is responsible for the conduct of a gas undertaking.

There are two more points to which I should like to draw attention. The purging of plant and apparatus does not, in my judgment, receive the importance that it deserves in this Report. The purging of plant by inert gases is something new to the Industry, but it is a measure of safety which I am sure must be very widely adopted. I am not referring specially to any particular form of apparatus which produces CO_2, but I am referring to methods that are readily available to all those in gas works—*i.e.*, the inert gases from the chimney shafts. During the last three years we have actually used the waste gases from our retort settings and conducted them by a pipe system to most parts of the works. In that way we have successfully purged gasholders as large as 6 million and 12 million cu.ft. capacity of the coal gas contained in the crown. I consider this question of purging one of prime importance.

I would also like the Committee to include in their recommendations for notices to be displayed, one prohibiting the switching on or off of electric hand lamps in an atmosphere which may contain gas.

Examination of Retort House Structures.

Mr. H. D. MADDEN (Cardiff): I recollect quite well the beginning of this Committee and the basis on which it was formed, because it was eleven years ago, when I was President, that we formed the Gasholder Committee, with the late Mr. Doig Gibb as Chairman, and later on I think Mr. Shapley was brought on to the Purifiers Committee. In those days this question of safety was a novelty, but I think to-day as evidenced by this Report, it is something that every gasworks must put on to a sound basis. In many cases too much is taken for granted. I heard of one case when I was Chairman of the Board of Examiners in which a man had been on the works ten years and had never seen the inside of his station governor. It had never been down for cleaning, and that sort of thing is quite wrong. I will go further and say that admirable as these rules are, I think we should go further still in the examination of structures, especially in the retort houses, and particularly horizontal retort houses, where you have steam from quenched coke eating into the steel staging or into the cast iron columns, and places like that should be inspected regularly. At Cardiff we have a system of inspecting all buildings, plant, hoppers, and everything else quite regularly to ascertain their condition. The reports are entered in a book, and repairs, where necessary, are put in hand at once. I have a particular instance in mind where a coke hopper failed, and it was due to the corrosion of the shanks of the rivet in between two sets of plates. Water had dripped from the coke being quenched and had caused the trouble, and it does appear to me that structures like that ought to be attended to.

There is another question I should like to refer to, and that is the fire-fighting arrangements on a works. There should be not only hoses, pails of sand, water, clay, or fire foam, but these should be regularly inspected to see that they are in working order. It is our practice every week for the man in charge to go round and enter the details in a book, and at regular intervals one of the assistant engineers goes round with him and checks that everything is in good order.

With regard to electric lighting on the works, I am in full agreement that you want to be particularly careful with the type of lamp you use and also with the wiring. I think this question of inspection of plant and precautions is a very necessary and vital one, and I think the Committee are doing excellent work in bringing before the members the real facts of the position as they have done in this Report. Mr. Andrews has spoken of the word "voluntary," and said he did not like it, but if we accept it in the widest sense and everybody employs the recommendations of the Committee, then I think the voluntary idea ought to suit Mr. Andrews.

Rules Should Be Adopted in Entirety.

Mr. G. C. PEARSON (Birmingham): I would like to stress that wherever possible these recommendations should be adopted in their entirety. Rules drawn up by a body of men must be better than the ideas of one individual, and as these Gas-Works Safety Rules have been drawn up by competent engineers after full discussion, I suggest they should be accepted in their entirety.

Reference has been made by Mr. Madden to fire-fighting appliances, and I would like to bring to the notice of the members what is perhaps a novel point in connexion with fire-fighting; I refer to the asbestos suit. I know that these suits to-day are expensive, but it is possible for a man in one of these suits to go into a room which is on fire and exist there for three or four minutes. We are very fortunate that in the Gas Industry accidents cannot be said to be a frequent occurrence. A useful safeguard for the prevention of accidents is the free ventilation of the circumstances of mishaps that may occur from time to time, thus affording guidance for the future avoidance of such occurrences. The recommendations and voluntary rules in the Report of the Gas-Works Safety Rules Committee therefore appears to me to be of extreme value, as these are drawn up in this manner for the benefit of the Industry. Any such information is of the utmost use and members of the Institution should without hesitation and in their own interests submit a full account of any untoward happening.

Should this practice be common in the Industry it may be worth considering the compilation of a technical dossier recording these incidents annually. While salient points emerging from such accounts would be embodied in the recommendations and voluntary rules, the source of such information would be considered confidential. Responsible officials, after study of this work, would be better equipped to come to that plant-conscious state of mind that is so desirable in foreseeing occurrences and prevention of mishaps. Should any accidents arise, the knowledge thus obtained and the prior consideration engendered should render a correct course of procedure immediately possible.

An additional incentive is that when accidents do occur on the gas-works they receive an undue amount of publicity in the Press, with consequent adverse effect on our Industry. I am therefore of the opinion that a study of this Report and its implications will conduce to the safety of plant and personnel.

Corrosion in Cups of Gasholders.

Mr. L. HARTLEY (Clayton, Son, & Co., Ltd.): There is one thing to be said in favour of the 1st Report of the Gas-Works Safety Rules Committee. It is not a lengthy document, but brief and to the point. The Committee is certainly to be congratulated on its production. Naturally I look on the Report from the Contractor's point of view, and probably read more into the various items than anyone who glances casually through them.

Section 2. Recommendations consists of five items only but each is of considerable importance. The first one "Voluntary Rules for the Safe Operation of Purifiers" is one I would strongly commend to all engineers. They are given as recommendations and called "Voluntary Rules" as Mr. Andrews mentions. I seem to remember certain other Voluntary Rules which were evidently acted upon, only in certain Works, while they were voluntary, but now have to be acted upon by all seeing they have been taken out of the category of Voluntary Rules.

The second recommendation calls attention to the corrosion

which sometimes takes place in the cups of gasholders, and suggests that they should be cleaned out annually. If you have this done, care should be taken not to move the rest blocks, which in many old gasholders are placed loosely in the bottom of the cup. If they are moved and the bearing is allowed to become unequal, it might cause serious trouble.

I have noticed that deposit in the cups and in the tank bottom can sometimes be traced to the fact that oxide is revivified near the gasholder, or coke is stored on an adjacent site and the dust is blown on to the gasholder. In such cases special care is necessary, and I would advise the building of a low wall round the tank where it is on the ground level. I have seen also cases where the tank is low, and the rain water has washed the adjacent earth into the tank.

Item C recommends two ways of preventing the water being syphoned from the cups by the antifreezer steam pipes. It is sometimes necessary in the case of holders throwing large pressures to keep the injector fairly low in the cup, so that when only one lift is on, the injector will still be immersed. In such cases the non-return valve is certainly advisable, but I have seen a very simple device adopted, that is, to drill a small hole in the top of the steam pipe on top of the dip. This also lets the attendant see that steam is actually going through.

Stresses in Spiral Holders.

I think the remaining items in the Report are useful to keep in mind, and call for no remarks from me, but I would like, Mr. President, with your permission, to refer to a paragraph in the previous Report just presented by the Research Executive Committee No. 187. On page 5, paragraph 4, it refers to a recommendation from the Safety Rules Committee, that a study be made of the stresses set up in spiral-guided gasholders. As Chairman of the Gasholder Section of the S.B.G.I., it is my privilege to be collaborating with Mr. Birks, representing the Institution in the carrying out of these experiments. I think this is a step in the right direction, and as a contractor I welcome the suggestion. It is one of the branches of our Industry where research has been neglected in favour of the chemical side. I think we all realize to-day that it is essential we should have reliable data to design our structures, and although spiral-guided holders have been working successfully since 1889, the calculations are all based on theory, and I hope proof will be forthcoming from the study of the stresses which is about to be undertaken. No doubt the research will be carried out assuming the holders are well constructed by experienced contractors, and that only stresses will be investigated which occur under normal working conditions. Of course, we allow a certain factor of safety, usually of 4, but I think the research should go further, and tests should be made to find out what stresses are set up under abnormal conditions. I have in mind such a case as a spiral holder where the tank has settled unevenly, and there are many such working to-day. What should be the limit allowable for a tank to go out of level before steps are taken to level it up?

It may be possible to follow with further experiments on these lines, and I am sure that any results obtained will be most welcome.

Such research as is now being undertaken may bring out other points of interest which will prove of inestimable value, and result in improving and cheapening the designs of the holder. I do not think anyone can maintain that the design of gasholders is perfect. There are variations in the life of holders that need explanation, and there are directions in which gasholder makers themselves are conscious that improvement is possible. We do not know enough about wind pressure for example. As gasholder makers we are not afraid of turning the spot-light of science on the art of holder design. It may be that modern practice will be confirmed, and if that is so, the practice that has been built up through the experience of generations of designers will have been proved, and we shall go about our tasks knowing that modern science can point no way of improvement. If our practice is found wrong and can be improved we shall not complain, for improvement is the object of anxious thought at all times, and the task to which we devote our brains and energies. Whichever way the research turns out, it is bound to yield valuable results and is well worthy of being undertaken.

In conclusion, speaking as a Member of the Council of the S.B.G.I., I would like to express my pleasure in collaborating with the production side of the Industry on this matter, and can assure you that the S.B.G.I. is willing at all times to act in collaboration with you, and I am confident that this procedure will be to the benefit of the Gas Industry as a whole.

Mr. C. M. CROFT (Wandsworth and District Gas Company): There is one point about the corrosion of gasholders that has not been mentioned, and it is one which we have suffered from at Wandsworth. That relates to having boilers in the middle of a works burning coke, with the result that grit gets into the cups and certainly does a lot of damage to the holders. We have prevented that type of damage to the cups by putting small walls round, as Mr. Hartley suggested. We have also found obstructions in the cups. In the case of one holder which has been working for 20 years we found a sling hook almost cut in half, and it had been there in the same position during the whole life of the holder. We also discovered a leak in the cups, and the method we adopted of stopping the leak I am afraid would not meet with the approval of others. There were countersunk rivets, and we could not get near them, and eventually someone had the brilliant idea of putting ordinary umbrella rubber rings on top of the rivet heads, and these held tight for six months.

With regard to discharging purifiers, I had hoped to be able to give you a little information about the discharging of the tar purifiers which we have recently installed at Wandsworth, but I am glad to say that as they have been working so efficiently up to date we have not had to change one yet. Therefore, I cannot give you any information, but we do use the purging machine on our biggest purifiers, and we find that by leaving the machine running for half an hour before we start we have absolute safety under all conditions of discharge. Another point is that we lift all the lids of our square boxes by means of steam cranes, and these are provided with steam from an outside steam ring.

Lastly, with reference to purifiers, we have no purifier buildings in Wandsworth now. We have pulled them all down, and our purifiers are all in the open. We find the expense of maintaining the roofs and buildings was very much greater than any parallel advantage from having them under cover, and we now build them without buildings. They get cold in the winter, but it is a simple matter to apply heat and keep them up to a working temperature. In our Company we have considered very carefully this question of safety, and an important thing is that you should train your men and not allow unskilled men in positions of danger.

Much Needed Foundation.

R. N. WEBB (Leeds): There is no doubt that the first report of the Safety Rules Committee lays down a new and much needed foundation for the works of our Industry.

The use of common methods for ensuring safety are very necessary, and it is only by the careful pooling of ideas on the subject that success will be achieved. It is up to all undertakings, large and small, to take a very serious view of the matter and to make a frank use of the recommendations wherever possible, and if considered necessary to add to them. With regard to the recommendation for purifiers and our existing methods:

(1) Notices are prominently displayed, having the wording "No Smoking by Anyone at Any Time and Naked Lights Strictly Prohibited" in the purifier houses and the immediate vicinity.

(2) Tests for oxygen content are made daily at the inlet to purifiers; no mention is made of this in the Report but we consider it advisable.

(3) It would be interesting to hear what are considered to be the best and most suitable type of fire-fighting appliances for purifier houses. Our practice is to have plenty of hydrants and hose available, with Phomenes placed in handy positions.

(4) Most of our boxes are worked with two layers of oxide. When the gas has cleared after lifting the cover, oxide is removed from the corners of each tier. All men stand clear for about 10 to 15 minutes to give the gas time to vent from below. Recently we have made use of white mice at the corners of the boxes after breaking through the oxide. Mice are very susceptible to cold and we have found them exhausted when no gas has been present.

(5) In the case of carburetted water gas purifiers our prac-

tice is to lift the lids and vent the tiers the previous day to discharging.

(6) With reference to the careful observation of box temperatures, it should not be overlooked that it is the oxide temperatures which matters and that thermometers fixed in the lids only give relative readings. We have found that when experimenting with upward flow boxes, the insertion of a long stem thermometer about 1 in. into the oxide surface showed temperatures 10° to 15° F. higher than those on the box thermometer.

(7) Purifier boxes situated in the open are usually subjected to the sun's rays, and consideration should be given to the spraying of the lids with water in order to keep down the temperature; where the lids are of curved shape this can be adopted without much difficulty.

(8) While we do not consider steel picks absolutely unsafe we make a practice of using bronze ones for opening up to vent the tiers; the difficulty with a bronze pick is to get one which will stand up to the work. Recently we have used a special type of bronze pick-head which has been a great improvement.

(9) When lifting the covers of water luted purifiers by hand-operated overhead cranes we always close the air valve as soon as the cover is free of the lutes and open it again when the operators have left the crane.

(10) Our practice is to empty and fill a box without cessation of the work, thus reducing the risks of fire when fouled oxide is left in the boxes.

(11) It is interesting to note that where boxes are in the open we have not had a serious mishap of any kind.

(12) We find that when taking a fully spent oxide from a box and passing it through the disintegrator not later than the second day and then heaping to about 12 in. until sold, it definitely reduces the dangers of firing, even when loaded into wagons.

(13) As soon as valve discs show the slightest signs of leakage these are removed, faces done up, and the valve made good.

(14) Centre valve covers are removed at frequent intervals, the faces examined and lubricated with black lead and tallow.

(15) Too much stress cannot be laid upon the necessity of having a recognized and trained man who can take charge of purifier working.

Testing of Gas-Works Valves.

It is very interesting to note that attention is drawn to the testing of valves; such work is naturally allied with general works safety measures.

Obviously many valves, owing to plant arrangement, cannot be thoroughly examined frequently, but improvement can be made by:

(1) Carefully recording the full particulars of the valves, position, number of turns, type of valve, direction of opening, and providing each valve with a definite record number.

(2) Such number and operating particulars should be placed in close proximity to all key valves.

(3) All valve glands should be accessible.

(4) Without exception, the usual trouble of leaky valves comes from either single faced rack and pinion or worm and rack valves. In my opinion, single faced valves should never be installed in future plant, the modern double faced valve as now made being much superior. A plan for the gradual elimination of such valves over a number of years will reduce maintenance and contribute to a better feeling of safety.

2nd Report of the Pipes Committee

Communication No. 192

I INTRODUCTION

During the past year the Pipes Committee has continued its work on revision of the Institution Specifications for Wrought Iron and has also considered the following draft British Standard Specifications:

(*a*) Dimensions and Workmanship of Asbestos Cement Spigot and Socket Flue Pipes and Fittings.

(*b*) Cold Rolled Mild Steel Strip for General Engineering Purposes.

The British Standard Specification for Rubber Joint Rings for Gas Mains, to which reference was made in the 1st Report of the Committee, has now been issued (No. 772-1938).

II ESCAPES OF GAS INTO CABLE DUCTS AND MANHOLES

The notes on (*a*) access to Post Office telephone jointing chambers, (*b*) methods of dealing with escapes of gas into cable ducts, and (*c*) a simple detector for carbon monoxide, which were published in the 1st Report of the Committee, have been reprinted with slight amendments and were published by the Institution, with the approval of the Post Office Authorities, on 10th June, 1938, under the title "Procedure for Dealing with Escapes of Gas into Post Office Plant."

Copies of this publication have been sent to all Gas Undertakings and to the Post Office Authorities for the information of their engineering staffs.

III FUSION BETWEEN ELECTRICITY AND GAS SERVICES

The Committee has considered information, supplied by each of the members, upon fusion between electricity and gas services. From the evidence available it would appear that there is little risk of such damage from modern types of cables provided reasonable precautions are taken to prevent close contact between the two services. The reports indicated that where trouble had been experienced it was generally due to deterioration or breakdown of cables laid in bitumen some 30 to 40 years ago.

IV WROUGHT IRON SPECIFICATIONS

The revision of the Wrought Iron Specifications has been completed and the following Specifications are given in the Appendices to this Report:

(i) Specification for Wrought Iron Bars for Gas-carrying Tubulars and Fittings (see Appendix 2).

This is a new Specification prepared in collaboration with the British Wrought Iron Association and relates to a form of Wrought Iron not dealt with in previous editions of the Wrought Iron Specifications.

(ii) Revised Specification for Wrought Iron Gas, Water and Steam Qualities Tubes and Fittings (see Appendix 4).

Clause 1 is reprinted exactly as in Section 2 of the 1930 edition, but the remaining requirements of that Section are to be replaced by those of British Standard Specification No. 788-1938, Wrought Iron Tubes and Tubulars, Gas (Light), Water (Medium) and Steam (Heavy) Qualities.

A revised list of approved British firms which are providing Wrought Iron Strip and/or Wrought Iron Bars to conform with these Specifications has been prepared in consultation with the British Wrought Iron Association and is given in Appendices 1 and 3 respectively.

V AIR RAID PRECAUTIONS

METHOD OF EXTINGUISHING FIRES IN GAS MAINS

The following account of experiments in the extinguishing of fires in gas mains is published in the hope that it may prove of value to Undertakings considering schemes for dealing

with damage caused to mains during air raids. The experiments described were carried out in the Distribution Department of The Gas Light and Coke Company and are published by permission of the Governor and Directors of that Company.

Under normal conditions gas escaping from a fractured main seldom catches fire, and even if it does the fire may usually be extinguished by packing clay round the main or filling in the excavation. Under air raid conditions the circumstances would be quite different in that (*a*) it might be expected that a section of main would be completely broken and two open ends exposed, (*b*) the crater would be too large to be filled in easily, and (*c*) ignition of the gas would most probably occur.

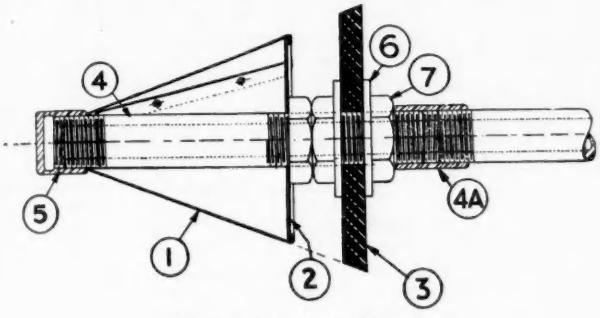


FIGURE 1.—*Mains Plunger.*

1. Cone Guide.
2. End Plate.
3. Rubber Disk.
4. ½-in. Connector.
4A. ½-in. Socket.
5. ½-in. Cap.
6. ⅞-in. Washer. (In all sizes over 4 in. dia. a metal disk is substituted for this washer).
7. ½-in. Back Nut.

The following experiments were made with a view to finding a quick method of extinguishing fires under the latter conditions, and it should be stressed that the method used has very little application under normal conditions.

The apparatus used in the first experiment was an ordinary mains plunger as shown in Figures 2 and 3, but the plunger shown in Figure 1 has since been developed and found quite satisfactory. As will be seen from the details in Figure 1 the plunger is assembled from standard fittings, except for the rubber disk and the metal cone.

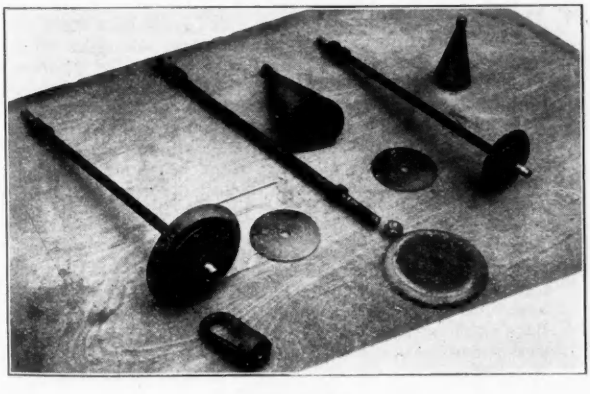


FIGURE 2.

The rubber disk may be cut from used conveyor belting of suitable thickness, so that there should be no difficulty in keeping a stock of disks, either ready cut, or in the form of used belts, at most of the medium or larger Works. The disks may be cut out roughly and then cut accurately and given the necessary taper on a lathe, using an ordinary parting tool, and clamping the rubber between two sheet metal disks.

The cone is the most troublesome part to make, but should not present any real difficulty on most Works.

The plunger shown in Figure 1 is attached to a 15 ft. length of ½-in. barrel, as shown in Figure 4.

For the purposes of the experiment four mains were laid with their ends exposed in an excavation made to resemble a bomb crater, it being supposed that a bomb had fallen on a four way connexion, consisting of one 8-in., two 6-in. and one 4-in. mains. This is shown in Figures 4, 5, 6 and 7.

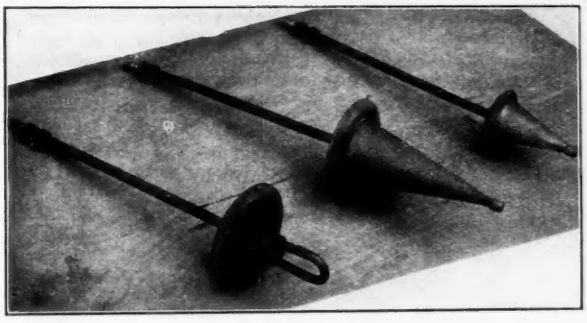


FIGURE 3.

The method of extinguishing the fire is to push the plunger into the main. Generally this will put out the flames completely, but even if they are not wholly extinguished they are so much reduced that it is an easy matter to stop up the end of the main with clay.

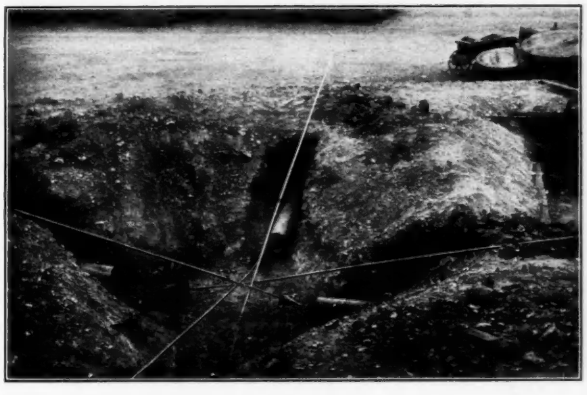


FIGURE 4.

It is possible to unscrew the length of barrel from the plunger and leave the plunger in the main until it is convenient for the repair of the main to be effected.

Figure 5 shows the four connexions alight.

FIGURE 5.

In Figure 6 the fire has been extinguished on one of the 6-in. mains (shown at the bottom) and the plunger is shown being pushed into the 8-in. main, whilst the other 6-in. and 4-in. mains are still alight.

Figure 7 shows the fires on the 8-in. and two 6-in. mains extinguished and the plunger just entering the 4-in. main.

The mains were supplied through a 3-in. service 150 ft. in length and tests were made with pressure losses up to 12 in. w.g. on this length, so that the flow would be about 12,000 cu.ft. per hr. It is, of course, very difficult to say what would be the volume of gas escaping from, say, a fractured 4-in. main on a low-pressure distribution system, as so much de-

FIGURE 6.

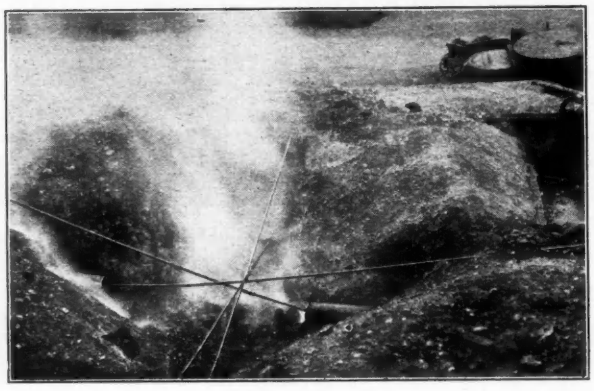


FIGURE 7.

pends on the size of trunk mains, pressures at station governors, etc. The above-mentioned pressure loss of 12 in. on 150 ft. of 3-in. service is, however, roughly equivalent to a loss of 5 in. in 100 yd. of 4-in. main, or 750 yd. of 6-in. main, so that probably the tests were fairly representative of practical conditions. It should perhaps be emphasized that the question of volume of gas escaping only affects the size of flame and difficulty of inserting the plunger—once that is inserted the full pressure on the main becomes effective and the pressure used in the tests, namely, 12 in. w.g., was much above normal district pressures. With the 15 ft. length of barrel attached to the plunger there was no difficulty in working against the flames obtained with the flows up to 12,000 cu.ft. per hr.

This method has also been used successfully on a 12-in. main.

APPENDIX 1

REVISED LIST OF APPROVED MAKERS OF WROUGHT IRON GAS, WATER, AND STEAM TUBE STRIP

This revised list, prepared in consultation with the British Wrought Iron Association, was issued on 6th October, 1938, in accordance with Clause 11 of The Institution of Gas Engineers' Specification for Wrought Iron Gas, Water and Steam Tube Strip, dated 9th February, 1927.

JOHN BAGNALL AND SONS, LIMITED, Wednesbury, South Staffordshire.
JOHN BRADLEY AND COMPANY (STOURBRIDGE), LIMITED, Stourbridge.
THE BUTTERLEY COMPANY, LIMITED, Codnor Park Works, Nottingham.
ETNA IRON AND STEEL COMPANY, LIMITED, Motherwell.
GEORGE GADD AND COMPANY, LIMITED, Church Lane Iron Works, Tipton.
HARTS HILL IRON COMPANY, LIMITED, Brierley Hill, Staffordshire.
N. HINGLEY AND SONS, LIMITED, Netherton Iron Works, Dudley.
JOHNSONS IRON AND STEEL COMPANY, LIMITED, Hall End Iron Works, West Bromwich.
LANCASHIRE STEEL CORPORATION, LIMITED, Warrington.
WILLIAM MARTIN, SONS AND COMPANY, Dundyvan Iron Works, Coatbridge.
MIDLAND IRON COMPANY, LIMITED, Midland Iron Works, Rotherham.
MONKS, HALL AND COMPANY, LIMITED, Warrington.
RAINE AND COMPANY, LIMITED, Grainger House, Blackett Street, Newcastle-upon-Tyne, 1.
SCOTTISH IRON AND STEEL COMPANY, LIMITED, 53, Bothwell Street, Glasgow.
SHEEPBRIDGE COAL AND IRON COMPANY, LIMITED, Chesterfield.
SMITH AND MCLEAN, LIMITED, 195, West George Street, Glasgow.
THOMAS WALMSLEY AND SONS, Bolton.

APPENDIX 2

SPECIFICATION FOR WROUGHT IRON BARS FOR GAS-CARRYING TUBULARS AND FITTINGS

This Specification was prepared, in collaboration with the British Wrought Iron Association, by the Pipes Committee of The Institution of Gas Engineers and adopted by the Council on 11th October, 1938.

1. The whole of the iron shall be rolled from bars made by puddling pig iron in puddling furnaces, and piles from which bars are rolled shall consist entirely of puddled Wrought Iron free from steel. Admixture of steel in any form will involve the rejection of the material.
2. Bars must be rolled to specified dimensions, must be true to gauge throughout their entire length (a tolerance of $\pm 2\frac{1}{2}$ per cent. being allowed), must be sound and free from laminations, flaws, cracks and defects of any description. Bars with jagged or broken edges or ends will be rejected.
3. Bars must be free from all "red shortness", must be workable at all temperatures from a dull red heat to welding temperatures without showing any sign of cracking, and must be of good welding quality.
4. Bars shall be of such quality that a clean sharp screw thread can be cut with hand dies on fittings made from the bars, without the fittings showing any sign of surface cracking or opening of the weld.
5. Analysis: Wrought Iron, to conform with the requirements of this Specification, shall contain not more than 0·15 per cent. of manganese and not more than 0·03 per cent. of sulphur.
6. Bars must be supplied under a certificate from the manufacturer to the effect that only genuine Wrought Iron has been used in their manufacture, and this certificate shall be a guarantee or shall be equivalent to a guarantee or warranty by the manufacturer that the bars have been made entirely from Wrought Iron as specified in Clause 1 hereof. The following declaration shall be signed by a

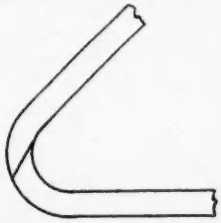
responsible official of the Company in whose works the material is actually manufactured:

"We hereby certify that the whole of the material represented by this invoice is genuine Wrought Iron made by the puddling process and that no steel has entered into its composition."

7. The purchaser or his nominee shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture of the bars at any stage and to reject any material that does not conform to the terms of this Specification. Inspection and tests shall not interfere unreasonably with the sequence of the works' operations.
8. From each three tons of material, two samples for test shall be selected and for smaller quantities one sample shall be selected. Should a test piece fail under test, two further samples shall be selected from the same batch of material. Should any of these fail, the material represented by the samples shall be rejected.
9. Samples shall be selected by the purchaser or his nominee, and test pieces cut therefrom shall be provided and prepared by the manufacturer, who shall also, at his own cost, supply labour and appliances for carrying out the following tests:
   (*a*) *Cold Bend Test.*—One piece cut from the sample in the direction of rolling shall stand bending without signs of fracture through an angle of 90° over a round bar the diameter of which is twice the thickness of the bar. The bending shall be done either in a press or by a succession of light blows without hammering directly on the bend.
   (*b*) *Cold Nicked Bend Test.*—One piece cut from the sample in the direction of rolling shall be lightly and evenly nicked on one side with a sharp cutting tool, and shall stand bending back at the nick without breaking in two pieces, and when so bent the fracture shall show a clean fibrous structure.

   Note.—When necessary, test pieces for the cold tests may be prepared by machining or filing their edges before bending.

   (*c*) *Welding Test.*—Test pieces shall be welded without showing any sign of "red shortness". The welded bar shall stand bending cold through 135° at the weld (as illustrated below) without showing any sign of opening of the weld:



10. The Institution of Gas Engineers will issue a list of approved British firms which are prepared to undertake to produce genuine Wrought Iron bars of British manufacture conforming with this Specification. Application to be placed on this list must be made to the Secretary, The Institution of Gas Engineers, 1, Grosvenor Place, London, S.W. 1.

APPENDIX 3

LIST OF APPROVED MAKERS OF WROUGHT IRON BARS FOR GAS-CARRYING TUBULARS AND FITTINGS

This list, prepared in consultation with the British Wrought Iron Association, was issued on 11th October, 1938, in accordance with Clause 10 of The Institution of Gas Engineers' Specification for Wrought Iron Bars for Gas-Carrying Tubulars and Fittings, dated 11th October, 1938.

JOHN BAGNALL AND SONS, LIMITED, Wednesbury, South Staffordshire.

JOHN BRADLEY AND COMPANY (STOURBRIDGE), LIMITED, Stourbridge.

THE BUTTERLEY COMPANY, LIMITED, Codnor Park Works, Nottingham.

ETNA IRON AND STEEL COMPANY, LIMITED, Motherwell.

GEORGE GADD AND COMPANY, LIMITED, Church Lane Iron Works, Tipton.

HARTS HILL IRON COMPANY, LIMITED, Brierley Hill, Staffordshire.

N. HINGLEY AND SONS, LIMITED, Netherton Iron Works, Dudley.

JOHNSONS IRON AND STEEL COMPANY, LIMITED, Hall End Iron Works, West Bromwich.

LANCASHIRE STEEL CORPORATION, LIMITED, Warrington.

WILLIAM MARTIN, SONS AND COMPANY, Dundyvan Iron Works, Coatbridge.

MIDLAND IRON COMPANY, LIMITED, Midland Iron Works, Rotherham.

MONKS, HALL AND COMPANY, LIMITED, Warrington.

E. PARKES AND COMPANY, LIMITED, Atlas Iron Works, West Bromwich.

RAINE AND COMPANY, LIMITED, Grainger House, Blackett Street, Newcastle-upon-Tyne, 1.

F. W. RATCLIFF AND COMPANY, LIMITED, Anchor Iron Works, Oldbury, Birmingham.

SCOTTISH IRON AND STEEL COMPANY, LIMITED, 53, Bothwell Street, Glasgow.

SHEEPBRIDGE COAL AND IRON COMPANY, LIMITED, Chesterfield.

SMITH AND MCLEAN, LIMITED, 195, West George Street, Glasgow.

THOMAS WALMSLEY AND SONS, Bolton.

APPENDIX 4

SPECIFICATION FOR WROUGHT IRON GAS, WATER, AND STEAM QUALITIES TUBES AND FITTINGS

This revised Specification was prepared by the Pipes Committee of The Institution of Gas Engineers and adopted by the Council on 11th October, 1938.

1 MATERIAL

Tubes shall be made from puddled iron supplied by one of the strip manufacturers on the scheduled list approved by The Institution of Gas Engineers, and it shall be one of the conditions precedent to a firm being placed upon this list that the firm agrees to supply to tube manufacturers purchasing strip from them, a certificate to the effect that the whole of the material represented by each invoice conforms with the clauses of the Specification of Wrought Iron Gas Tube Strip drawn up by The Institution of Gas Engineers. Such certificate shall be shown by the tube manufacturer to the buyer of tubes, on application by the latter.

2 OTHER PROPERTIES

In addition to Clause 1 above, the material shall comply with all the requirements of British Standard Specification No. 788-1938, Wrought Iron Tubes and Tubulars, Gas (Light), Water (Medium) and Steam (Heavy) Qualities.

Mr. H. J. ESCREET (Chairman, Pipes Committee) introduced the Report.

Discussion.

Mr. DEAN CHANDLER (South Metropolitan Gas Company): The inclusion in the Second Report of the Pipes Committee of The Institution of Gas Engineers of a slightly amended specification for wrought iron strip for making tubes to be used for carrying gas, and the publication of a revised list of approved makers, provides a timely occasion for one or two appropriate and I think relevant observations.

The original specification for wrought iron which was first issued by The Institution of Gas Engineers in 1927 was at that time considered to be of first-class importance to the Gas Industry, because, in the light of experience, this material was believed to be at that time superior to steel, so far as corrosion is concerned, for conveying gas to consumers' premises and to gas burning appliances.

The provisions embodied in the original specification were

the result of a great deal of investigation and research by the Committee which had been appointed by the Institution to deal with the problem. I can say from personal knowledge that the specification was the result of a very thorough and painstaking investigation. I would add that when the original specification was submitted to the Council of the Institution it was welcomed and referred to as a valuable and important specification, which, if adopted and adhered to in practice, would do much to avoid trouble and expense in the future.

There appears to be some suggestion that to-day the conditions of gas supply are so changed that the substitution of steel for wrought iron can now be justified. This possibly may be sound for gas undertakings supplying "dry gas," but to agree that the substitution of steel for wrought iron is justified without reference to the circumstances and the conditions of gas supply which exist is, I think, unwise and may have very unfortunate results.

There must still be many undertakings in the country who have not yet adopted gas dehydration, and experience has shown that for moist gases wrought iron is the more suitable material and this for two reasons. First, the actual amount of corrosion is less with wrought iron, and, secondly, the wrought iron corrosion products are, in general, of much coarser size and therefore less liable to be carried forward by the gas stream to be deposited at points where there is a considerable change of direction or section of the pipe and to those points where the gas issues through the orifices of gas-consuming appliances.

An examination of the deposits from mild steel and wrought iron pipes which we recently took up after about thirty years' service showed that the rust on a sieving test gave the following results:

Result of Sieving Test. (B.S.I. Sieves.)

Passing.	Retained by.	Ratio. Wrought Iron Rust. Steel Rust.
—	¼	7·0
¼	18	2·0
18	52	0·6
52	85	0·4
85	200	0·5
200	—	0·4

If steel is to replace wrought iron for use with moist gas, it must be treated internally with some effective and durable protective medium, and I think we should hesitate to abandon the well-tried wrought iron in such circumstances until there is available a greater body of established satisfactory experience with internally coated pipes.

It has been suggested that before long it may be very difficult to obtain wrought iron pipes. I have a shrewd suspicion that this suggestion is being circulated for purely commercial reasons and that there is no real justification for it. If the Gas Industry insists on having wrought iron tubes, it will get them—that is, provided the Gas Industry does not allow itself to fall entirely into the hands of the steel interests.

Wrought iron is certainly a more costly material, but in certain circumstances the extra cost in the long run will in all probability be fully justified.

Specification for Rubber Rings.

Mr. P. RICHBELL (Croydon): With regard to specification for rubber rings, we found when the rings used by my Company were tested for tensile strength in accordance with specification that they were required to comply with a figure of 3,500 lb. per sq.in. as compared with 2,000, 1,500, and 1,000 lb. per sq.in. for the soft, medium, and hard grades included in the specification. The type of ring used by my Company is also used by a number of other companies, and it is suggested that when the specification is revised additional classes of rubber should be included.

In connexion with escapes in cable ducts and manholes the circulation of the notes by the Institution has clarified the position and assisted in the relationship between the two public services. I would, however, like to emphasize that friendly relationships and co-operation with the local engineers assists enormously in dealing with these cases and any other matters which have to be negotiated with this Department.

I notice in the section dealing with wrought iron specification that the Council of the Institution have approved an amended specification for wrought iron bars for gas conveying tabulars and fittings. The British Standard Specification, 788-1938 requires the strip to be manufactured from genuine wrought iron, and in the Institution specification the manufacturers are required to certify that the material is genuine wrought iron. If under that specification the material is required to be genuine wrought iron, I have wondered why the Institution specification could not have been incorporated in the B.S.I. and thus avoid the necessity of referring to two specifications when ordering this class of material.

Now we have an up-to-date specification for tubing, I would like to ask if this Committee could investigate the question of coatings for tubing. A number of the manufacturers are producing a hessian with bitumen coating which is suitable for use in medium class soils and avoids the necessity of using the expensive pitch and troughing method of protection, which it is only really necessary to use in very bad subsoils. If a standard type of coating could be evolved it would be of great benefit to the Industry.

The section dealing with extinction of fires in mains which have been set on fire during air raids is very interesting, and I feel the thanks of the whole Industry are due to the Chairman of this Committee and his staff for the investigations which they have carried out. In the rural districts where occasionally mains have no alternative feed, it has occurred to me if a larger diameter tubing could be used for a plunger a flexible tube could be connected to two plungers on each side of the fracture and a temporary supply restored until such time as permanent repairs could be effected. I am afraid, however, a plunger of this type might be too heavy to manipulate on a 15-ft. length of ½-in. tubing. However, it might be worth trying.

Fires from Broken Mains.

Mr. R. J. RESTALL (Stalybridge): I propose to limit my comments to the section of the Report concerning the Committee's attempt to overcome fires from broken mains. The importance of our activities which have anything to do with Air Raid Precautions cannot be stressed too much, and for those of us who are unable to experiment to the same extent as others I should like to ask one or two questions.

With regard to the rubber disk on the stopper which has been developed, I should like some information concerning the effect of fire on the edge of that rubber. Further, could the stopper be used for mains of large size; it has occurred to me that the weight of the stopper to be used in a main of 12 in. or more diameter might be too great to allow of its insertion into a broken main.

In Figure 4 there is a picture of mains with exposed ends, and I note that they are shown square cut. In practice, however, I think we should find that, as the result of an explosion, the edges of a broken main would be serrated, and if the projection on the main were on the top side I anticipate that it would be very difficult to insert the stopper. On the other hand, if the projection were on the under side of the main it might give a lead for the stopper to enter the main. I should like to know whether that aspect of the situation has been considered.

Then there is the question of the depth at which an explosion would occur. Is there any possibility that the amount of earth dropping back into the newly-formed crater would help to fill up the hole made? Personally, I think that is very doubtful, for the dispersion of the material would be so terrific.

Any attempts made to protect our public works are most commendable, and therefore the information before us is very much appreciated. I should like to make two suggestions which perhaps the Committee would consider. In the first place, I suggest that we might approach the War Office in order to ensure that we are working on the right lines, as well as the Fire Office and some eminent fire brigade specialist.

Secondly, a practical suggestion I would make is that these fires might be put out by concussion—by using pretty well the same means as has been used to destroy the main junction.

The CHAIRMAN (Mr. George Dixon): Perhaps I may instance an experience I have had with regard to pipes. I

have already referred it to the Pipes Committee, but it interested me, and it may be of interest to others present. It is in connexion with bends on wrought iron services. We have found in Nottingham, and probably the same experience is common to all of you, that the back outside radius of the bend is the weak point of all service pipes. The matter came to my notice because I was asked whether I could see any advantage in a thread protector that was coming on to the market, and I enquired as to whether the threads were in fact the weakest points in service pipes. The investigation led very definitely to the conclusion that the thread was not the weak point, but that the weak point occurred on the back of the bend. I have examined a great number of bends taken from service pipes, and I have found that the corrosion is always on the outside radius, whereas there is no sign of corrosion on the inside of the bend—*i.e.*, the smaller radius; there is no corrosion at all of the inside bore of the service pipe or of the bend. Some 75 per cent. of our service failures during the last two years have been at that same part in the bend, and that experience rather led us to feel that in the manufacture of the bend there was some straining or some change in the crystalline structure of the metal which rendered it more liable to attack by corrosion. You know, of course, that bends are made from the straight pipes, whereas other fittings, such as the tees and elbows and so on, are made on the anvil in a different way.

In view of our experience, I put the question to the Chairman of the Pipes Committee as to whether there is some change in the nature of the metal which renders it more liable to attack by corrosion. If that is not so, then I have to seek some other explanation of this particular phenomenon.

Mr. Escreet's Reply.

Mr. ESCREET: I am much obliged to Mr. Dean Chandler for his remarks with regard to wrought iron, which served to support the issue of the specifications by the Institution.

With regard to the point raised by Mr. Richbell as to the reason for the wrought iron bar specification, I am afraid that the heading used is rather misleading, if not inaccurate, in referring to "tubulars and fittings." The bar specification is really required for fittings which are not made from tube, but which are worked up from the bar, and that was the reason for producing that separate specification.

With regard to coatings, there are very good pipe coatings for the straight barrel, but the difficulty is to deal satisfactorily with the joints and the bends. As Mr. Dixon has pointed out, there is often corrosion on the backs of bends, and I feel that the only real way to provide against corrosion is to use troughing over the whole thing. The Committee is giving the matter careful consideration. So far as I know, there has been very little work done on it, and it may be a matter for careful investigation by some outside authority on behalf of the Institution.

Various points have been raised by Mr. Restall concerning the plunger for extinguishing fires in gas mains. Fire does affect the rubber disk to a certain extent; that is to say, after it has been used a number of times it begins to wear a little round the edge, and it will be necessary to carry spare disks.

The limiting size of main for which the plunger can be used, I think, is pretty definitely 12 in. As we have said in the Report, we have used it on a 12 in. main, but I think that 8 in. is really a comfortable limit. Certainly I should not advise its use for any main larger than 12 in.

The mains on which the tests were made were not cut off square at the ends, but were rather jagged, although they do not appear in that condition in Figure 4. Unless there is serious under-cutting, I do not think there will be any difficulty in getting the plunger in.

I quite agree with Mr. Restall that the chances of the debris falling back into the crater after an explosion are very small. In the only bomb experiment that I have seen, the whole of the debris seemed to vanish entirely; it was collected over the next two or three fields, I think.

The extinguishing of a fire by the use of another explosive would be possible, no doubt; but I think that if a main is alight, it is just as well to leave it alight until you can control the gas. If you simply put out the flame by another explosion with CO_2 or something of that sort, the gas will continue to escape and it will probably ignite again.

29th Report of the Refractory Materials Joint Committee

[ABSTRACT]

Communication No. 193

I SUMMARY

The Action of Alkalies on Refractory Materials

Since investigations on this subject were commenced in 1933, the study of the interaction with refractory materials of alkali chloride vapours in particular has claimed considerable attention. Two further Papers in the present Report are devoted to a further consideration of certain aspects of alkali chloride action. The first is concerned more especially with the mechanism by which small amounts of various constituent oxides of the refractory may be caused to migrate to the surface or be entirely volatilized. It is shown that complete volatilization is favoured by reaction of the clay or silica refractory with sodium chloride under dry conditions in an inert atmosphere, whereby some conversion of the brick constituents to volatile chlorides takes place. Migration of oxides to the surface of the refractory is found to be favoured by reaction with sodium chloride in the presence of dry air or oxygen. It is concluded that conversion to chlorides takes place within the refractory and re-conversion to oxides at the surface. In some instances the iron oxide so concentrated at the surface has been found to promote the decomposition of carbon monoxide and the growth of carbon aggregates under suitable conditions of temperature. Migration or volatilization of oxides present in the refractory is considerably reduced when reaction with sodium chloride occurs in the presence of steam.

In a second Paper the alteration in transverse strength on exposing various refractory materials to the action of potassium chloride vapour at 1,000° C. is considered. Appreciable changes in the modulus of rupture are reported, but these are not found to be related to the changes in dimensions of the specimens. (The expansions occurring on submitting refractory materials to alkali chloride vapours have been dealt with in the 27th and 28th Reports.) Other factors intervene, such as the development of glassy material and the effect of heat treatment in itself.

An interesting industrial example of the effect of sodium chloride in coal is also dealt with in the present Report. A vertical silica retort had been operating with a salty coal for a number of years at moderate carbonizing temperatures. On examination, the brickwork of the retort was found to be fairly normal on the coal side, but considerably attacked on the flue side. In the regions of highest temperature at the top of the retort the silica brickwork was considerably thinned by erosion and was thoroughly glazed. In the regions of lowest temperature at the bottom of the retort considerable expansion of the retort wall had occurred, causing disintegration on the flue side. The samples examined indicate that cracks and fissures caused by the expansion had become filled with molten glass draining from higher up the retort wall on the flue side, possibly intensifying the distortion. At the same time sections from the interior of the brickwork which were apparently unchanged showed an appreciable reduction in refractoriness due to contamination with soda.

The Effect of Hydrocarbon Gases on Refractory Materials

The effects of methane and of town gas in causing the disruption of certain types of firebrick at about 800° C. have been described in the 26th, 27th, and 28th Reports. A further investigation of the action of methane has now been made

with particular reference to the mechanism of the disintegration. The evidence indicates that after a somewhat variable period of induction in which the iron spots are brought to a reactive condition methane decomposes directly into carbon and hydrogen. The growth of the carbon depositions around the iron spots brings about the disruption of the firebrick. In some cases the iron spots are not activated and such firebricks resist disintegration.

The Action of Slags on Refractory Materials

The commencement of a fresh investigation of the subject of slag action was described in last year's Report. It dealt with the action of four lime-alumina silica slags on various silica, clay, and aluminous refractories, using three contrasting methods of testing. As a development of this work the corrosive action of lime itself has now been studied, and an account is given in the present Report. For clay products the depths of corrosion (in which the brick structure is obliterated) are found to decrease roughly as the alumina contents increase, but the depths of penetration of liquid products beyond the corrosion zone are found to be at a minimum for bricks of about normal fireclay composition.

The Refractoriness-under-Load Test

The recognized variants of this test are the increasing temperature-constant load method (the usual procedure) and the maintained temperature-constant load test. An examination of these tests formed the subject of contributions to the 25th, 26th, and 27th Reports. A third variant, the maintained temperature-increasing load method, was considered with respect to firebrick materials in the report for last year. These products usually undergo increasing deformation in this type of test. In continuation of the work, a section of the present Report is devoted to an examination of the behaviour of silica bricks, materials which usually fail in the test by shearing. With these products it is found that the results are subject to appreciable variation, but average values can be used with advantage to discriminate between the different brands available. It is interesting to note that silica bricks are unable to support a load of 50 lb. per sq.in. for long periods at temperatures more than 50° C. below those at which failure occurs in the normal method. The relative merits of the different variants of the test are briefly discussed in the Report.

Experiments on the Behaviour of Sillimanite Mixes on Being Pressed

Previous Reports have stressed the importance of the pressing operation in relation to the "texture" of refractory materials, particularly sillimanite and silica brick mixes. This year, in continuation of the work described in the 26th Report, an investigation has been made of the variation in different parts of the pressed block of the proportioning of the various grain sizes. The results are found to depend on the type of pressing—whether from the top only, from the top and bottom simultaneously, or from the top and bottom successively. In addition, the granular constitution of the original mix is shown to exert a marked effect on the type of variation obtained.

The Measurement of Apparent Porosity

Measurements of the apparent porosity of refractory materials are a routine determination in all laboratories concerned with these products. Nevertheless, it has been appreciated for some time that it is a difficult measurement to perform accurately and that different methods yield different results even on the same specimen. In the present Report an account is given of the measurement of apparent porosity of 19 specimens by several types of procedure and an attempt made to evaluate the inherent and random errors associated with each method.

Jointing Cements

Previous Papers on this subject have largely been concerned with an examination of the refractory properties of synthetic silica, sillimanite, and fireclay cements. In particular the behaviour of these mixtures under load and under tension at high temperatures has been described. The third section of the present Paper is devoted to a review of the properties of 22 commercial cements of various types. The results obtained on applying the usual refractory tests as well as those obtained by the procedure mentioned above are detailed in the Paper. In addition some attention is given to the measurement of the working properties of the cements and the behaviour of the cements in three tests devised for the purpose is also recorded. In general, the cements appear to have adequate workability, but a number seem inferior in mechanical stability at high temperatures to the bricks with which they would be used.

Other Researches

A review of the progress of research on refractory materials in 1937 has been published in Bulletin No. 46 of the British Refractories Research Association.

A progress report and a list of researches carried out by the British Refractories Research Association of indirect interest to gas engineers are included.

Mr. GEORGE DIXON: We have to receive and discuss the 29th Report of the Refractory Materials Joint Committee. Before I ask Mr. Grogono, the Chairman of the Committee, to introduce the Report, I would like to say there is a reference in the Report to the death of Dr. Mellor which, unfortunately, as you know, took place just prior to our last June meeting. Dr. Mellor, you are aware, was the Director of the Research Association and did a tremendous amount of work. He was always interested in any work that had a bearing on the activities of the Institution and I just feel that while the Committee places on record its recognition of Dr. Mellor's work and the loss which it has sustained to his passing, those who are present in this room this morning would also like to be associated with that. I thought I would like to make that remark from this Chair before I ask Mr. Grogono to deal with the Report.

Mr. WALTER GROGONO (Chairman, Refractory Materials Joint Committee) and Mr. A. T. GREEN (Director, British Refractories Research Association) introduced the Report.

Discussion.

Mr. T. F. E. RHEAD (Birmingham): It is always a pleasure to take part in the discussion on the Refractories Report, because one is so justified in paying tribute to the good work executed at Stoke.

The present comprehensive report is full of interest and valuable information. For example, the work on alkalis carries us a step further in unravelling a very complicated problem. The potent effect of sodium chloride in causing volatilization of various constituents is easily seen. I have recently found this alkali work very helpful in considering the compounding of cements for spray welding. I would like to know more about the reactions of alkali compounds with refractories, and particularly their volatility characteristics—*e.g.*, in what chemical combination does the sodium atom remain stable up to the limits of temperature the refractory itself can safely withstand? Phosphates, sulphates, carbonates, silicates, etc., rise to one's mind.

The increase in volume of refractories by absorption of alkali vapour brings to mind an idea tried out by me many years ago—namely, that the opening of joints in silica retort walls might be due to the possibility of shrinkage being brought about by absorption of fluxes. Many experiments were tried on silica test pieces, using half a dozen different fluxes—ferruginous and alkali in nature—but no shrinkage was noticeable. The present work prompted the looking up of these results, and in several cases distinct expansion was noted, supporting the work in the present report.

Another subject of great importance is that of jointing cements. These may be likened to the patent medicines of the retort house. There is a plethora of these recipes, and while some are good and compounded on sound lines, there are many which are worthless—even dangerous—and, moreover, they vary in composition and grading from consignment to consignment. The care of spraying cements is even worse.

I am glad the British Refractories Research Association are pursuing this subject—a vital one for the Industry—and

it is to be hoped some rough specifications will be forthcoming to keep out the charlatan.

The methods adopted in the report of testing the properties of unfused cements are of great interest, and a serious attempt has been made to study separately those factors which, when suitably combined, go to make up the "brickie's" conception of "workability."

Working on the Same Lines.

Dr. A. L. ROBERTS (Leeds University): There is one point that Mr. Green mentioned which, I think, involves the definition of academic work, and particularly academic work in this field. By academic work I think we mean, in the narrower sense, that academic work which is carried out because of the interest in the work itself and not necessarily because of the interest in the results, but to-day particularly in a department such as the Fuel Department at Leeds, I think it is safe to say that the academic work is carried out first for the interest of the work itself and secondly on account of the interest and the bearing of that work on the Industry. In that respect I think we and Mr. Green are working along the same lines and that we are doing real fundamental work which is being applied to the solution of problems in industry. Particularly is that the case in connexion with this work on the slagging of the fluxed material mentioned in this Report, and also mentioned last year. The fundamental work in that connexion is the identification of the products of the reaction which is yielding results of great interest in themselves, and, I also think, of great benefit. I should like to ask Mr. Green in connexion with this work whether in the future he will consider it necessary to adopt the X-ray method for identifying the products of the reaction or whether he thinks the microscope will suffice.

There is another point of detail, perhaps, in connexion with the work reported upon this year. Mr. Green has established the presence of two zones, one of corrosion in which the original texture of the brick is pretty well obliterated and, below that, a zone in which the slag has penetrated but apparently has not obliterated the texture of the brick to any great extent. So far as I interpret the Report, there are no obvious indications that the penetration has upset the texture of the material, and I wonder how far it is true to say that it will have its effect in ways that are not at once visible—*i.e.*, does the penetration cause alteration, say, in the thermal expansion characteristics. If it does then one might expect that the tendency of the material so penetrated by slag would be, for instance, toward structural spalling, the formation of zones due to thermal expansion.

I was very interested in the work on the effect of hydrocarbons on the refractory materials and particularly in the point relating to the rôle played by iron spots in permitting decomposition of methane. I hope Mr. Green will continue with that work and try to account for the delayed action, I mean infinitely delayed in some cases, of certain types of iron spots. That seems to me to be a point of academic interest in the narrowest sense but, at the same time, it is one of distinct practical importance.

Another section of this Report in which I was very interested is the comparison of the different methods of determining porosity. During the last few years I think many of us must have been struck by the accuracy of the methods employed in testing refractory materials. For instance, thermal conductivity was under examination about a year ago and now the Association has done a very good piece of work in comparing porosity methods. I wonder if Mr. Green intends to expand the range of the porosities of the materials compared. I notice it goes up to about 25 per cent. but I am wondering how far the comparative accuracy of the various methods established by this work will hold when materials like insulating materials with from 70 to 90 per cent. porosity are investigated.

Complete Gasification of Coal and Methane Synthesis

Progress Report of Experiments at the Fuel Research Station

by

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Communication No. 197

[ABSTRACT]

In the 39th Report of the Joint Research Committee of The Institution of Gas Engineers and Leeds University,* attention was drawn to an important change in the programme of work undertaken by the Committee, in which it is proposed to study methods for the complete gasification of coal so as to produce gaseous mixtures not dissimilar to those derived from the direct carbonization of coal. It was also recorded that a Joint Committee, with Mr. E. V. Evans as Chairman, had been formed with representatives of the Fuel Research Board to ensure full consideration of the problems which would arise in connexion with the research programme.

The important results which have already been obtained by the research workers of The Institution of Gas Engineers have been recorded in Communications Nos. 141, 167 and 190, published by the Institution. During the course of this work the problem of complete gasification has been attacked in other directions at the Fuel Research Station and the object of this Paper is to present a brief report of the progress which has been made. The experimental work has followed three distinct lines.

1. The gasification of bituminous coal in a water-gas plant, using plant of existing type, but modified methods of operation.
2. The synthesis of methane from mixtures of carbon monoxide and hydrogen.
3. The complete gasification in a special reaction chamber of finely-divided coal with steam and oxygen under pressure.

The first programme was started in order to determine whether it was possible to adapt a normal water-gas generator to convert coal to permanent gas containing no uncracked tar vapours. Successful results have been obtained with South Wales coals containing up to 18 per cent. of volatile matter and also with bituminous coals of high volatile matter and low caking power. It is considered that the medium-volatile caking coals should not be treated in this manner, especially as coals of the above type can be successfully treated.

The second programme was concerned with the examination of the properties of catalysts for the production of methane. If it were proposed to gasify coal completely in water-gas plants, or by existing methods of complete gasification, the gas produced would be of relatively low calorific value and would have to be enriched in order to make it suitable for modern requirements. A possible means for such enrichment lies in the use of catalysts for the synthesis of methane from carbon monoxide and hydrogen. Catalysts of this type were already well known at the time the experiments were started but it was recognized that these were not necessarily suitable, owing, for example, to the fact that they were readily poisoned by sulphur compounds. It was considered desirable, therefore, to explore the possibility of finding a catalyst which would be resistant to sulphur compounds

* *Trans. Inst. Gas Eng.*, 1936–37, **86**, 120.

and yet would possess sufficient activity to produce methane at a high space velocity. If such a catalyst were to become available, a two-stage process for the complete gasification of coals could readily be evolved. The experimental work in this programme is still going on. Although a completely satisfactory catalyst has not been found, the results show considerable promise.

The third programme is concerned with the gasification of pulverized coal with oxygen under pressure. The vortex chamber, originally designed for the combustion of pulverized fuel, is being adapted to this purpose. Early experiments at the Fuel Research Station have shown that a chamber 3 ft. in diameter will gasify 400 lb. of coal per hr. and release as much as 500,000 B.Th.U. per hr. per cu.ft. of vortex space. It was proposed to adapt this chamber to work under pressure with steam and oxygen to gasify coal so that methane would be synthesized to an extent sufficient to produce a gas of 500 B.Th.U. calorific value. It was hoped that this might be achieved without losing the high rate of gasification obtained when using the chamber as a burner. The remarkable promise of such high rates of gasification made the proposal particularly interesting. Experimental work has been confined so far to atmospheric pressure using a small-scale chamber. Information has been obtained regarding the method of feeding the pulverized coal and the steam and oxygen necessary for gasification. Designs have been prepared for an experimental plant to work under pressure, and this plant is now being constructed.

The experimental work is being carried out by Mr. D. MacDougall, Mr. H. Bardgett and Mr. G. Percival (water-gas experiments), Dr. C. M. Cawley (molybdenum catalysts), Dr. L. A. Woodward (cobalt catalysts) and Mr. R. V. Thomas (vortex-generator).

GASIFICATION OF COAL IN WATER-GAS PLANTS

The possible replacement by coal of the coke normally gasified in a water-gas generator is of interest to the Gas Industry directly under conditions where the coke market is good. In the consideration of schemes for complete gasification it is of interest as a means of producing a high yield of gas directly from coal without the necessity of producing coke as an intermediate product. Since the gas produced would necessarily be of low calorific value, however, the application of the process would entail a second stage involving either continued enrichment with oil or the development of a satisfactory methane-forming catalyst. It follows that the first stage of the complete process could be served either by adapting existing plants or by the introduction of plants specially designed for complete gasification. A further object was the provision of synthesis gas for conversion into liquid hydrocarbons.

The experimental work was carried out using a Humphreys and Glasgow "blue gas" generator of 500,000 cu.ft. per day rated capacity.

The first coal selected was a South Wales coal sufficiently low in volatile matter to give the minimum trouble with tar, and of slight caking power to avoid either disintegration or undue coking in the fuel bed. Large amounts of coal of this type are available in South Wales and elsewhere.

The methods adopted were to vary the cycle of operations so that the coal was carbonized on the surface of the hot fuel bed before up-running was attempted. After preliminary experiment it was found necessary:

(*a*) To provide a supply of air to the top of the generator to burn the blow gas and raise its temperature high enough to carbonize the coal charge quickly.

(*b*) To introduce the down-run steam into the stack to superheat it as much as possible.

After some experiments several variations of operating cycle were found to be satisfactory for sized coal. The best of these are set out in Table 1.

In method A there was an appreciable loss of time during the 9½-min. period allowing for the carbonization of the fresh charge of coal, since the amount of steam supplied was only sufficient to prevent leakage of gas through the reverse make valve. In method B the coal was charged first and the top of the generator heated up later during 2 min. by burning producer gas made at a slow rate. The supply of top air was adjusted according to the appearance of the flame issuing from the stack. Downward steaming at the full rate was then possible without producing tar.

Table 2 illustrates the effect of the two schemes when using South Wales coals of nut size containing up to 17 per cent. of volatile matter. As determined by the Gray-King assay these coals had potential tar contents of up to 7·6 gal. per ton.

The greater rate of output of gas under the conditions of method B is important. The gas contained no tar vapour

TABLE 1.—*Methods of Operation, A and B*

Operation.	Method A.	Method B.
1	2	3
1	Blow for 1·5 min. burning the blow gas in the generator.	Charge 4 cwt. coal with top air slightly open.
2	Make producer gas for 2 min. and burn in the generator.	Open blast valve slowly to full open, with 4 lb. per min. of up-run steam, burning gas with top air for 2 min.
3	Charge 4 cwt. of coal.	Steam down for 3·5 min. with 12 lb. of steam per min.
4	Supply down-steam at 2 lb. per min. for 9·5 min.	Steam "up" for 0·5 min.
5	Steam "up" for 0·5 min. (purge).	Up- and down-running for 4 to 7 cycles of 4 min. each with 1 min. blows.
6	Up- and down-running for 4 cycles of 4 min. each with 1 min. blows.	Up-run for 2 cycles of 4 min.
7	Up-run for 2 cycles of 4 min. each to heat up the top of the fuel bed.	

from either method. A number of other South Wales coals of different screen size and caking power were examined in order to assess the effect of these variab'es. The general conclusions from these experiments were:

(i) Non-caking coals tend to give low outputs of gas owing to the eventual choking of the fuel bed.

(ii) Medium-caking power ensures a porous fuel bed and a relatively high output of gas.

(iii) Cobbles of non-caking coal are not appreciably better than nuts but either can be improved appreciably by blending with not less than 20 per cent. of medium-caking coal.

The highest rate of gasification was obtained with medium-caking cobbles and was 17,120 cu.ft. per working hour or 206 therms per ton of coal. This improvement over the figures recorded in Table 2 was due mainly to the non-disintegration of the fuel bed.

The thermal efficiency of the process was 63·8 per cent., as compared with 62·5 per cent. obtained by J. G. King and J. F. Shaw* when operating the same generator on sized coke. The output of gas obtained for sized coke was 17,000 cu.ft. per hr., a similar output to that obtained from the coal.

COALS HIGH IN POTENTIAL TAR

Satisfactory results having been obtained with coals containing less than 7·6 gal. of tar, attempts were made to treat weakly-caking coals of high tar content and high in volatile matter. It was realized that coals of intermediate volatile matter would be too highly caking and could not be gasified by the methods adopted. Alterations were therefore made to the plant so as to use an auxiliary recuperator as a cracking chamber and a former waste-heat boiler as a condenser to separate for measurement any tar vapour which might remain uncracked to permanent gas. The essentials of the technique were as follows:

(i) Combustion of the blow gases in the top of the generator and in the recuperator using both "top air" supplies. To achieve this the stack was placed after the recuperator.

(ii) The passage of the volatile matter from freshly-charged coal either through the hot fuel bed or the heated recuperator.

* Fuel Research Technical Paper, 6, 1923.

TABLE 2.—*Yields from Carbonaceous and Bituminous Coals*

Method.	A.	B.	C.			
1	2	3	4	5	6	7
Steam supply, lb. per min	16·0	14·0	—	—	—	—
Air pressure, in. water	20	20	—	—	—	—
Coal:	S. Wales	S. Wales	S. Wales	Northumberland	Scottish	H.T. Coke
Volatile matter, per cent.	16·8	10·6	14·5	36·2	36·9	—
Potential tar, gal. per ton	5·6	7·6	7·6	33·6	32·3	—
Moisture, per cent	0·8	0·8	0·9	8·6	9·2	3·6
Throughout per 24 hr., tons	5·75	4·98	6·46	7·22	9·10	6·90
Depth of fuel bed, ft.	6·5	6·0	6·5	7·0	7·0	7·0
Gas yield per ton of coal, cu.ft.	67,140	63,780	69,080	45,705	42,460	63,580
therms	204·8	204·1	210·0	141·2	130·4	184·4
Gas calorific value, B.Th.U.	305	320	304	309	307	290
Gas per working hour, cu.ft.	12,400	14,500	18,970	15,570	18,320	21,200
Gas made per lb. of steam, cu.ft.	26·6	25·1	23·6	23·3	30·8	24·0
Gas composition, per cent.:						
CO_2	4·8	2·5	5·0	6·0	6·5	5·9
C_nH_m	0·3	0·2	0·3	0·9	0·5	*Nil*
O_2	0·1	0·1	0·7	0·2	0·3	0·1
CO	34·8	35·8	32·9	33·2	33·6	41·3
H_2	52·9	55·6	50·9	50·9	51·2	50·7
CH_4	1·8	1·9	2·6	2·6	3·2	*Nil*
N_2	5·3	3·9	7·6	6·2	4·7	2·0

(iii) The supply of the steam to the base of the recuperator as in a "back-run" process. This served the double purpose of preheating the steam and gasifying usefully any carbon deposited by cracking on the brickwork of the recuperator. The steam supply to the recuperator was not used.

A preliminary run on a South Wales coal of the type already gasified (volatile matter 14·5 per cent., potential tar 7·6 gal. per ton) gave a gas yield of 19,000 cu.ft. per working hour, as compared with 17,000 cu.ft. obtained when gasifying under the conditions of method B.

When, however, weakly-caking sized coals of 35 to 37 per cent. of volatile matter containing 32 to 34 gal. of potential tar per ton were tried, it was found impossible to achieve complete cracking of the tar vapours and about 2·5 gal. per ton of coal of heavy tar (specific gravity 1·31, solids 43 per cent.) was recovered from the condenser. Trouble due to excessive pressure in the scrubber was experienced in the early experiments with these coals, the pressure being caused by deposits of tar and sludge. It was found that the gas produced during up-runs contained the most tar and modifications were made to the operating cycle by reducing the proportion of up-running and spacing it more uniformly over the cycle. These modifications gave much more satisfactory operating conditions. The most suitable cycle of operations in this modified plant when using a South Wales low-volatile coal, a Northumberland and a Scottish high-volatile coal, and for comparative purposes a high-temperature coke are shown in Table 3, the gasification results being included in Table 2, method C.

TABLE 3.—*Method of Operation, C.*

Coal.	Blow, Min.	Run, Min.				Steam, Lb. per Min.
		Up.	Down.	Back.	Up.	
1	2	3	4	5	6	7
South Wales:						
1 cycle	—	—	—	3½	½	Back-run 20
2 cycles	1	—	—	3½	½	Up-run 14
1 cycle	1	1	—	2	1	Back-run 24
4 cycles	1½	1	—	2	1	Up-runs 14
2 cycles	1½	3	—	—	—	Up-run 14
Northumberland:						
6 cycles	1½	½	—	2½	½	Back-run 23
4 cycles	1½	½	2½	—	½	Up-run 15
Scottish:						
5 cycles	1½	½	—	2½	½	Back-run 20
1 cycle	2	½	—	2½	½	Up-runs 12
2 cycles	2	3½	—	—	—	
H.T. Coke:						
1 cycle	1½	4	—	—	—	Back-runs 22
3 cycles	1½	½	—	3	½	Up-runs 16
1 cycle	1½	4	—	—	—	
3 cycles	1½	½	—	3	½	

With this system of operating, the temperature of the recuperator were held at from 850° to 900° C. Experiments had previously shown that variation of this temperature from 650° to 900° C. had little effect on the calorific value of the gas.

It has been shown that:

(*a*) Sized carbonaceous coals of low-caking power can be gasified successfully in a water-gas plant to yield about 67,000 cu.ft. or 205 therms of gas per ton of coal.

(*b*) The output of gas per working hour is similar to that obtained when using sized coke.

(*c*) High-volatile coals of low- or medium-caking power can be gasified by using a recuperator and introducing a back-run into the cycle. The yield of gas is about 45,000 cu.ft. or 141 therms per ton of coal. The rate of output of the generator is about 15 to 25 per cent. less than when working on sized coke in the same plant and up to 18 per cent. less than when gasifying carbonaceous coals. A small proportion of the tar (about 2·5 gal. per ton of coal) escapes cracking and means must be provided for recovering this from the gas.

(*d*) By modifying the cycles of operation, coal can be gasified to give a gas having a high ratio of hydrogen to carbon. Such a gas would be of value in connexion with processes for the catalytic synthesis of hydrocarbons.

Dr. J. G. KING introduced the Report.

Discussion.

Professor D. M. NEWITT (Imperial College of Science and Technology): I should like to refer to a part of Dr. King's Paper dealing with the synthesis of methane from carbon monoxide and hydrogen. I have discussed it with one of Dr. King's assistants, and perhaps he will allow me to give briefly the subject-matter of our discussion. At the Imperial College at South Kensington we have made methane now for many years by this process of synthesis from carbon monoxide and hydrogen; but, of course, we use pure gases, so that this question of sulphur poisoning does not arise. We have always used a nickel catalyst, which has been promoted by a little thorium oxide, but we have also used other promoters, such as zirconium oxide and titanium oxide. We use nickel in preference to cobalt as we find that with cobalt there is a considerable formation of higher hydrocarbons even at temperatures such as 350°.

We have also carried out a few experiments, by no means complete, on the effect of sulphur impurities in the gas, and they are the experiments to which I should like to refer. Of course, this question of catalysts is a very thorny one, and one in regard to which any speaker will tread very warily. We find that the addition of a promoter to the nickel catalyst renders that catalyst rather more sensitive to heat effects—that is to say, there is a loss of activity due to the heating of the catalyst, which heating is in turn due to the fact that the catalyst has been rendered more active. We found that in carrying out comparative experiments it was necessary to support the catalyst in such a way that we could conduct

the heat away from it, and also to dilute the reacting gases with some inert gas so that the amount of heat evolved was comparatively small. We found that to be absolutely essential in order to follow out the change in the activity of the catalyst with time. When we did that we found that the results confirmed very largely those of Dr. King, that there was a slight loss of activity during the first few hours, but the catalyst tended to assume subsequently a state of permanent activity and it remained in that state as long as our experiments lasted, which was as long as 30 or 40 hours. Of course, that does not tell us very much.

Then the question of the effect of space velocity on the catalyst, as to whether CO_2 or steam is formed in the synthesis, is again, I think, a question of the heating of the catalyst due to its great activity, and that, of course, is proportional to the space velocity.

I think that represents all we have done at South Kensington, and on the whole it confirms Dr. King's conclusions, although I think it leads one to hope that there are not insuperable difficulties in obtaining a catalyst which is quite rugged enough for practical use with a gas containing sulphur.

Dr. A. TAYLOR (Department of Scientific and Industrial Research): The question of the production of methane from carbon monoxide and hydrogen has interested me, to my cost, in past years, in my attempts to make higher alcohols from carbon monoxide and hydrogen under pressure. My difficulty was to avoid making methane, and in the attempt to avoid it I used sulphur catalysts; cobalt sulphide, nickel sulphide, and iron sulphide were associated with copper and manganese in the form of a catalyst, but under no conditions was I able to obtain less than 50 per cent. of methane in the resulting gases. So that it seems to me that the problem of the production of a catalyst to meet the case of the technical gases is not a very difficult one.

A Comparison of Processes.

Dr. F. J. DENT: I am very pleased that Dr. King has presented this interesting report. It is on work which is largely complementary to that being carried out at Leeds. We, as you know, have been mainly concerned with investigating the possibilities of producing hydrocarbons by hydrogenation but there is the equally important alternative, which has been engaging Dr. King's attention, of producing the hydrocarbons by interaction of carbon monoxide and hydrogen.

Each process has its characteristics. Thus, as a means of enriching gases obtained by the gasification of fuels in steam, hydrogenation has the advantage of increasing the output of the gas as well as raising its calorific value, in much the same way as carburetting does in the water gas process, and this increase in output will help to support the expense of the enriching stage.

On the other hand, when producing hydrocarbons from carbon monoxide and hydrogen, no additional fuel is gasified in the enriching stage and the heat contained in the final gas is less than the heat contained in the mixture of carbon monoxide and hydrogen obtained by gasification. As a result, when the hydrocarbons are produced by interaction of carbon monoxide and hydrogen, the amount of fuel to be gasified in steam per therm of final gas is approximately twice the amount to be gasified when the hydrocarbons are obtained by hydrogenation. In consequence of this, it is especially important for the carbon monoxide process that gasification in steam should be carried out as efficiently and cheaply as possible. Fortunately, the gas required from the gasification for the carbon monoxide process need not be so rich in hydrogen as for the hydrogenation process, so that loss of efficiency due to using excess steam to obtain a gas rich in hydrogen can be cut down.

The hydrogenation process can be arranged so as to leave a non-caking residue which should be ideal for a rapid gasification in steam, whereas, when enriching by interaction of carbon monoxide and hydrogen, the coal must be gasified in steam directly or subjected to some special treatment to prevent caking. Dr. King is alive to this position and shows in his report that this factor may not be of decisive importance. Certain coals, at least, he has accommodated in a water gas generator and, of course, we have American experience along these lines. There is also the possibility that Dr. King will be successful in using caking fuels in the pulverized form in his vortex chamber.

The hydrogenation process is independent of catalysts with their attendant sources of trouble, but, with the progress that is being made, we can take it as most probable that those troubles will eventually be overcome. When that is achieved, it appears to me that the carbon monoxide hydrogen process will be more flexible than hydrogenation in enabling the product to be readily varied from gaseous to liquid hydrocarbons when the demand for gas is low. This, I think, will be a most important advantage.

As we now picture it, a hydrogenation process for the production of gaseous hydrocarbons is vastly different from the hydrogenation process for the production of liquid hydrocarbons and it seems that if a works were laid out to produce relatively widely varying amounts of both gaseous and liquid hydrocarbons by hydrogenation, it would always have a considerable part of its plant lying idle, and so defeat the aim of utilizing off-peak load facilities. On the other hand, when synthesizing hydrocarbons from carbon monoxide and hydrogen, variation from a gaseous to a liquid product will mainly be a matter of regulating the temperature of the catalyst chamber with little requirement for additional plant.

Under the conditions in which we are operating the hydrogenation reactions, methane is the only stable hydrocarbon. That is the reason why high yields of methane can be obtained rapidly from the complex mixture of structures present in the original coal substance. Unless very high pressures are used, obtaining quantities of liquid hydrocarbons, or gaseous hydrocarbons other than methane, requires that the reactions be stopped at a half-way stage and a broad view suggests that this will be more likely of achievement with a simple homogeneous starting material such as carbon monoxide.

Only thorough investigation will tell us which of the processes, or whether a combination of the two will be most usefully applicable to the Gas Industry.

Research Very Much Alive.

Mr. E. V. EVANS (Chairman, Research Executive Committee): I made the statement this morning that in my opinion, and in the opinion of my colleagues on the Research Executive Committee, research in the Gas Industry is very much alive. Now, at the end of the first day of this meeting, I wonder whether those of you who have heard the discussions here can realize what a delight it is to be associated with these committees, including the Joint Committee of the Fuel Research Board and this Institution on Gasification. I happen to be an officer of one of the London gas undertakings, and it is never necessary for me to go to a cabaret show or to anything of that nature for entertainment; I am completely entertained by my duties as Chairman of the Joint Committee of the Fuel Research Board and the Institution, a position of which I am very proud.

The Author's Reply.

Dr. J. G. KING: Reference has been made by Professor Newitt to his experience with catalysts in his own work. I was already aware of that, as he said; nevertheless, any information of that kind which can be made available to us in pursuing our work on the synthesis of methane must be of eventual value to us in carrying out the programme.

We have heard from Dr. Taylor that in his particular branch of catalyst work he found it less easy to produce liquid hydrocarbons—alcohols in his case—than to produce methane; but I think that, had he been working on the other side of the house, trying to produce methane, he might have found the same difficulties as we did.

I was very interested in Dr. Dent's remarks concerning the relative possibilities of hydrogenation, synthesis, and gasification processes in general, but I should like a little more time in which to think carefully about what he has said before I venture upon a reply. I think the best way in which to look at that particular side of the problem at the moment is to consider that we should investigate all the promising lines of attack and then, when each has reached a sufficiently definite stage, we should decide which is the most promising direction in which to proceed. I feel sure that Dr. Dent will agree with that.

Institution Gas Fellowship Report, 1936-38

The Influence of Furnace Atmospheres on the Scaling of Mild Steel at Temperatures from 1,200° to 1,400° C.

Communication No. 196

by

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Institution Gas Research Fellow,

and

J. W. COBB, C.B.E., B.Sc., F.I.C.,

Livesey Professor

[ABSTRACT]

In 1936, the Gas Research Fellowship Report by H. C. Millett and J. W. Cobb* dealt with the subject of the scaling of mild steel in different furnace atmospheres free from or containing sulphur-dioxide, most of the experiments having been carried out at a temperature of 1,000° C. Fuller information is plainly desirable. Materials other than mild steel are now widely used and subjected to furnace treatment and the Alloy Steels Research Committee of the Iron and Steel Institute has assumed responsibility for continuing that branch of the investigation in the Leeds laboratories. Of equal importance, in view of the extent to which temperatures above 1,000° C. are used in furnace work, is the extension of experimental work to such temperatures, and this is the subject of the investigation described herein on which the Institution Gas Research Fellow has been working for the last two years. The use of much higher temperatures has necessitated modification in the experimental methods employed, although they have been retained as far as possible. The enhanced rate of reaction made it necessary to use much smaller times of exposure to the furnace atmospheres, *e.g.*, 5 min. instead of 1 hr., and this exposure was to be exactly regulated if the desired precision in results was to be forthcoming. Moreover, a much higher rate of flow in the atmosphere had to be employed (and the necessary rate ascertained) if the "critical velocity" was to be reached. Above this critical velocity the scaling results were reliable and dependent on temperature and composition of the atmosphere but not on the rate at which the atmosphere was supplied.* The results obtained are given in the Summary which follows. The most obvious results forthcoming are:

(*a*) The enormous effect in increasing scale production of the use of the higher temperatures as compared with the effects of the presence of free oxygen or sulphur dioxide.

(*b*) The bad effects of sulphur dioxide, although these become relatively of less importance at high temperatures.

(*c*) The comparatively small effects in reducing scaling of carbon monoxide when used in such quantities as 4 per cent. An interesting point brought out was the rapid rise in scaling rate which occurred when the liquefying temperature was approached, followed by a comparatively slow rate of increase with temperature when liquid scale had been formed.

SUMMARY

Experiments have been carried out to determine the scaling effect on heating a mild steel in the products of combustion of a fuel such as coal, oil or producer gas at temperatures from 1,200° C. to 1,400° C. The synthetic atmosphere taken as representing these gases consisted of 10 per cent. carbon dioxide, 10 per cent. water vapour and 80 per cent. nitrogen. The influence of the presence of excess air, of a shortage of air and of sulphur dioxide in the gaseous atmosphere has been studied, as well as the effects of temperature, period of exposure and gas velocity. The following results were obtained:

1. The critical velocity of the gases to be attained or exceeded for constant results as determined by W. E. Jominy and D. W. Murphy and by H. C. Millett and J. W. Cobb was found in their experiments to be dependent on temperature, surface area of the specimen, and composition of the atmosphere. At the high temperatures now used, it was found that for a longer time of exposure the critical velocity was smaller, and presumably it diminished as an experiment proceeded. For the shorter periods of exposure such as 5 min. used at 1,200° C. to 1,400° C., a much higher velocity had to be used than had been employed for exposures of 1 hr. at 1,000° C. The gas rate employed in subsequent experiments was 300 l. per hr., which represents a velocity of 55·8 ft. per min. at 1,200° C., 59·4 ft. per min. at 1,300° C. and 63·2 ft. per min. at 1,400° C. At temperatures above the melting point of the scale, critical velocities were too high to be determined with the present technique.

2. At temperatures above 1,000° C. the effect of the neutral atmosphere increased greatly. Whereas at 1,000° C. the increase in weight over a 1 hr. period, as previously determined, had been 0·0075 g. per sq.cm., at 1,200° C., it was found in these experiments to be 0·0446 g. per sq.cm. in ½ hr., and at 1,300° C. scaling for ¼ hr. caused an increase of 0·0614 g. per sq.cm.

3. The addition of oxygen to the neutral atmosphere also caused a marked increase in the rate of scaling. 4 per cent. of oxygen added from 50 to 100 per cent. to the amount of scale formed in the neutral atmosphere at the temperatures used.

4. Carbon monoxide reduced the scaling to some extent. The addition of 4 per cent. of this gas reduced the amount of scale formed in the neutral atmosphere by about 15 per cent., but the effect of each increment of carbon monoxide fell off slowly as the concentration of carbon monoxide increased.

5. The scaling effect of sulphur dioxide increased with temperature, but its effect above 1,000° C. was less marked on account of the greatly increased amount of scaling caused by the neutral atmosphere alone. The ratio,

$$\frac{\text{Increase in weight in the presence of 0·18 per cent. } SO_2}{\text{Increase in weight without } SO_2}$$

decreased from 4 to 1·3 as the temperature increased from 1,000° C. to 1,330° C.

Above 1,300° C. 4 per cent. oxygen had a more deleterious effect than 0·2 per cent. sulphur dioxide.

6. The combined effect of oxygen and sulphur dioxide at temperatures above 1,200° C. was approximately the sum of the two individual effects, whereas at lower temperatures the influence of sulphur dioxide had been found to disappear in the presence of more than 3 per cent. of oxygen.

7. Carbon monoxide caused some reduction in the scaling effect even in the presence of sulphur dioxide, but the decrease was smaller than that produced in the absence of sulphur dioxide. The scaling produced in a sulphur-containing atmosphere with 4 per cent. of carbon monoxide was from 3 to 6 per cent. lower than that formed in the sulphur-containing atmosphere with no carbon monoxide. The influence of varying amounts of carbon monoxide was roughly linear, but very large quantities of this gas would plainly be required to eliminate scaling completely.

8. The oxide scale produced in the neutral atmosphere had a melting point of 1,340° to 1,350° C.

At temperatures higher than this, rapid formation of liquid scale occurred, the amount of scale being

* *Trans. Inst. Gas Eng.*, 1935-36, **85**, 610.

† In the extreme case, when the temperature was high enough to liquefy the scale, this was not found possible, the scaling continuing to increase with velocity of flow.

dependent on the gas velocity and directly proportional to the time of exposure. If a critical velocity exists at these temperatures it is very high. At temperatures below the melting point of the scale the effect of time on scaling could be expressed by the formula, $W = kt$, where W = increase in weight, t = time of exposure, k = a constant and n is an index the value of which varies between 1 and 2 according to the temperature of experiment and the constitution of the atmosphere. In general, the value of n decreased with increasing concentrations of sulphur in the atmosphere, and with increasing temperature, although the effect of temperature on n was small until the scales began to show signs of fusion. Curves calculated by the use of this formula, for the same time of exposure, bring out clearly the magnitude of the temperature effect on scaling.

Professor J. W. COBB and Mr. ALAN TAYLOR (Institution Gas Research Fellow) introduced the Report.

Discussion.

Dr. J. STEWART: I have very little to say, but it may interest you to know that the electrical people working with electrically heated furnaces make a gas from carbon, getting CO only and avoiding the presence of hydrogen entirely. They work with less than 20 per cent. CO. I know very little about their experience, but I have made a calorimeter for measuring that amount of CO. Their experience ought to be of some use to us. The particular Company doing this is Birmingham Electric Furnaces, Ltd.

Mr. W. CLARK JACKSON (Neath): I feel that this particular form of research work is going to prove very useful indeed to the Gas Industry. I am glad to see that research is now getting into our industrial field of work. Those of us who have tried to develop the industrial side of our business in connexion with steel, whether it be rolling mills for making black sheets or white sheets or tinplates as in South Wales, have had a very great difficulty in getting at any figures or any records whatsoever to assist us in our work. Now that research is being applied to the industrial side of our business the position is very much improved, but I trust that the Committee will go further than the simple oxidation effects or the effects on the steel at these high temperatures. I hope that they will also take up the effects of scaling on bars going into the rolling mills themselves. We have spent many months in conjunction with the technologists of the steel industry to try to make town gas suitable for heating the furnaces in tinplate work. In the case of sheets heated by coal fired furnaces they have what they call roll marks, which are a serious trouble, as they consist of soft spots on the sheets when rolled out. If you take a sheet 20 in. square there are little soft spots here and there which attach themselves to the rolls and tear the sheet coming through the next pass. After months and months of work we got rid of this to a certain extent, but we did not get to finality, with the result that our experimental work has had to be discontinued temporarily. Therefore, I trust that more attention will be given to the use of town gas for industrial work.

Hot Patching of Retorts by Blow-Pipe Spray Welding

Communication No. 198

[ABSTRACT]

by

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Spray Welding Process and Achievements

The successful repair of leaks in gas retorts while hot is a problem, the solution of which makes for considerable economies in the cost of retort maintenance. At present, attempted routine repairs are carried out on many Works by spraying and gunning with slurries and pastes of refractory cement and water, though with very limited success owing to poor adhesion of the cement. The use of wet material on a hot retort has never really appealed to common sense, and there have been several advocates for experimenting with dry materials. Laboratory work on these lines was carried out by the British Refractories Research Association and others, including the City of Birmingham Gas Department. The valuable work of the British Refractories Research Association was presented to The Institution of Gas Engineers in the 23rd* and 24th† Reports of the Refractory Materials Joint Sub-Committee in 1932 and 1933. Large-scale retort house work in Birmingham on the problem has recently resulted in the evolution of a successful and practical process for repairing leaks in continuous vertical retorts.

In Section III. of this Paper the Authors describe the process, which in essence consists of spraying a refractory cement through an oxy-coal-gas flame, the cement forming adherent patches of fused material and filling up the leaks. The burner and cement feed device are described in detail and also the technique of carrying out the repairs.

The process has now been in use for 8 months on two continuous vertical ranges, one making 10 mill. cu.ft. per day and the other 2 mill. The repairs thus effected have made it possible to postpone cold repairs which would otherwise have been necessary, and the cost of hot repairs has been halved compared with the previous cost of repairs using wet materials.

Theoretical and Practical Considerations

In Section IV the subject is discussed from the point of view of the fundamental properties of surface tension, adhesion and cohesion. The relationship to other processes which depend upon the adhesion of powders and granular materials, *e.g.*, pottery glazing, vitreous enamelling, consolidation of metallic powders, refractories manufacture, etc., is shown.

It is felt that only the fringe of the subject of adhesion of refractory powders and granular materials has been touched, and that much more work should be done on this subject. There seems no inherent reason why, for example, it should not become possible to reface refractories *in situ*. This and other possibilities are envisaged in the Paper. Other matters discussed refer to those properties of powders, etc., which affect pneumatic conveying, texture of patch, and the like. The significance of the welded interface and the properties of the patch in relation to the type and condition of the refractory undergoing repair are also discussed.

Experimental

In Section V is given a progress report on the preliminary investigations concerning dry spraying cements, burners and cement feeds.

As regards the spraying cements, several fluxes and crushed graded refractories and mixtures thereof are being tested.

* *Trans. Inst. Gas Eng.*, 1932–33, **82**, 728.
† *ibid.*, 1933–34, **83**, 281.

Many of the 200 tests so far carried out are given in tabular form and somewhat reservedly discussed; typical photographs of the test-pieces are given. The apparatus and technique adopted, and the general behaviour of materials undergoing the process are described. Preliminary experiments with burners and feed devices are mentioned. With regard to feed devices, a description is given of one which has been designed to overcome certain limitations connected with the uniform feeding of powders.

A few tentative recommendations are made concerning the compositions of spraying cements.

INTRODUCTION

Gas retorts invariably develop small leaks after a period of work. These leaks permit escape of coal gas into the combustion flues where the coal gas may ignite and the local high temperature encourage further growth of the leaks. A leak in the hottest zone of any type of retort is most troublesome, as there is uncombined air for combustion of the escaping gas. Depending upon the type of retort, holes in this zone may or may not be closed by deposition of scurf. In any case, periodical removal of scurf re-opens the leak for a time. After an extended period of work leaks eventually become unmanageable, and the retorts have to be let down cold for patching or re-building.

In an endeavour to check leakage and prolong the periods between extensive cold repairs, it has been common practice for many years to carry out hot repairs with cement and water paste or slurry. According to the location and size of holes in the retort walls, the paste or slurry has been applied by means of paddle, gun or spray. The use of patching materials in the wet form on a red-hot retort wall, however, gives only a poor adhesion of the patch, and the process cannot claim to effect a permanent repair. Despite limited faith in the application of wet material, these methods of repair have been systematically pursued on many Works as the only available means of affording any relief from leakage troubles.

In 1931, during the discussion on the wet-spray hot patching work of the British Refractories Research Association (22nd Report of the Refractory Materials Joint Sub-Committee*), one of the Authors suggested that dry material might be used in conjunction with the local application of heat to the point of repair by means of an air or oxygen-coal gas flame. It was mentioned that experiments on these lines were being initiated at the Test Works at Birmingham. In the 23rd Report,† similar work by the British Refractories Research Association was described. Cement powders with varying proportions of fluxing material gave more or less adherent deposits when introduced into an air-coal-gas blowpipe flame impinged upon a refractory brick. It was considered "probable that only the more refractory mixtures used could be applicable to vertical retort work." One of the conclusions reached was that "although a large amount of work remained to be done with regard to the cement compositions and grain sizes, as well as that of the flame temperatures, sufficient indication of the usefulness of the method has been given, provided it is possible to devise a suitable appliance for Works use."

In the 24th‡ Report of the Refractories Materials Joint Sub-Committee further developments by the British Refractories Research Association were reported. Experiments had been carried out in the use of powdered aluminium and silicon mixed with crushed silica. The rapid oxidation of the silicon or aluminium at the point of application provided part of the heat for fusion of the applied material.

As a result of the work described in the 23rd and 24th Reports, difficulty was anticipated in projecting the powdered cements upwards, and it appeared that repairs to vertical retorts would be more effectively carried out from the top than the bottom.

In the early part of 1938 experiments were independently carried out at the Windsor Street Works of the Birmingham Corporation Gas Department, in an endeavour to apply cement in a semi-fused, plastic condition to refractory bricks. So successful were the experiments that a process was evolved and apparatus designed by which leaks in vertical retorts could be repaired from the top or bottom of the retort with considerable success. A range of upwardly-heated vertical retorts, with a capacity of 10 mill. cu.ft. per day, and only 15 months old, had developed leakage to such an extent that a cold repair would be required after a few months. The process of repair by welding was commenced on this range in February, 1938, and the condition of the retorts has been so improved that cold repairs have been avoided, and on present indications should be postponed for some time. Another range which commenced to show small leaks after nine months' work has been treated by this method, and is "bottle-tight" after 15 months' work. The repair of recuperators, although not yet attempted, is suggested as a further application of the welding process.

It can be claimed, therefore, that the smaller leaks can be effectively repaired by this means, and the process offers an efficient and practical method of preventing the growth of leaks providing it is applied soon after leakage commences to show. In these circumstances there is every promise of effecting substantial reduction in the cost of retort maintenance. Settings usually have to be reconstructed long before the greater part of the refractories has worn out, involving considerable wastage of material and labour. Consequently any successful process of hot repair should result in considerable savings in the cost of refractories per ton of coal carbonized.

Further development work for perfecting and extending the application of the process is described in Sections IV and V of this Paper.

SPRAY WELDING PROCESS AND ACHIEVEMENTS

Description of Apparatus

The apparatus consists of an oxy-coal-gas blow-pipe burner (without premixing chamber) connected with oxygen and gas supply tubes and a refractory cement powder feed device, together with high-pressure oxygen cylinder, reducing valve, safety valve and flexible oxygen and gas connecting tubes. The assembly of the complete apparatus is illustrated in Figure 1.

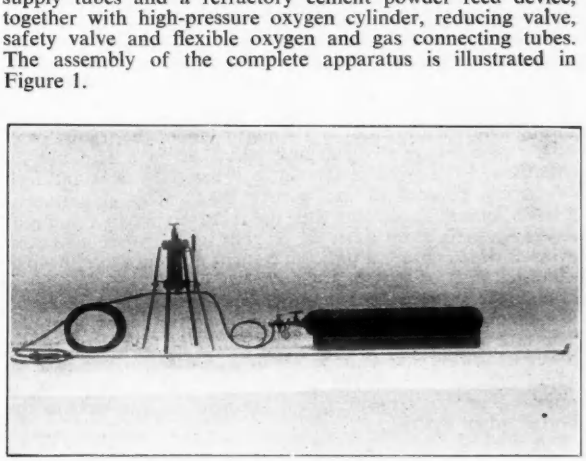

Figure 1.—*Assembly of Burner.*

The Burner

The burner is constructed of concentric tubes of inside diameter $\frac{5}{16}$ in. and $\frac{3}{4}$ in. of Firth's "F.D.P." heat-resisting steel. All joints are welded, as screwed joints alone will not remain tight in the high temperature conditions obtaining in the retort, and a leak between the inner and outer tubes will rapidly cause a collapse. The oxygen nozzle at the burner tip is of a special heat-resisting steel, Firth's "Immaculate 5", and its diameter of 0·07 in. and position relative to the gas nozzle, have been determined by practice. Provision is made for the different expansions of the inner and outer tubes, and for prevention of twisting of the inner tube whilst attaching or removing the flexible tube from the cylinder. The gas and oxygen consumptions are 100 and 60 cu.ft. per hr. respectively.

The burner described gives a small intensely hot flame capable of fusing the refractory material fed to the point of repair at a rate of 1½ to 2 oz. per min., and the most satis-

* *Trans. Inst. Gas Eng.*, 1931–32, **81**, 356.
† *ibid.*, 1932–33, **82**, 746, 748.
‡ *Trans. Inst. Gas Eng.*, 1933–34, **83**, 286.

factory repairs have been achieved with this rate of feed. It has not yet been found possible to speed up the work by increasing the dimensions of the present design of burner. Although the process is at present limited to localized repairs, work is proceeding towards the design of a burner capable of building up retort faces over a considerable area.

Cement Feed Devices

One of the forms of cement feed is shown in Figure 2. It is interposed in the oxygen line to the burner. In passing

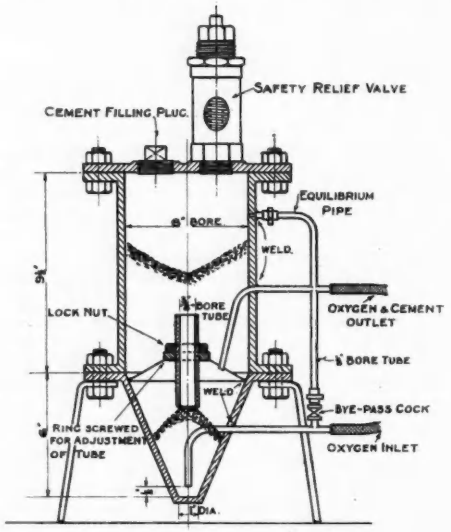

Figure 2.—*Cement-Feed Device; Wash-Bottle Type.*

through this device the oxygen picks up cement powder and carries it to the burner head, whence it flows through the flame and is impinged upon the retort wall at the position of the leak and builds up in a semi-molten condition. The process demands a perfectly constant feed of cement powder to the burner head. This requirement proved somewhat difficult with the relatively small volume of oxygen passing at 60 cu.ft. per hr., but feed devices have been evolved which ensure a uniform cement flow upwards through a burner 16 ft. in length.

Figure 2 shows a feed of the " wash bottle " type designed to maintain a constant level of powder in the lower chamber. The rate of feed is related to the volume of free space in the lower chamber, and can be set at a predetermined rate by adjustment of the internal screwed tube. A by-pass tube is provided so that oxygen, free from powder, can pass to the burner when desired.

Refractory Cement Powders

Commercial silica sand can be fused with the above burner if desired by suitably retarding the rate of feed. Repair work, however, is greatly facilitated if a somewhat more fusible cement is employed. Success has so far been achieved by using the grade 60 to 120 I.M.M. sieved out of various pointing and patching cements. The one chiefly used of this grade had the percentage analysis

SiO_2, 90·0; Al_2O_3, 5·7; Fe_2O_3, 0·4; TiO_2, 0·3;
CaO, 0·5; MgO, 0·15; Na_2OK_2O, 0·25; Loss on ignition, 2·8,

which showed it to be highly siliceous and to depend, to a large extent, on the small amount of clay content for its binding. The material had to be dried before use to facilitate feeding into the oxygen stream by the device described. It is hoped that a wider range of suitable refractory cements will be forthcoming from the laboratory work in hand, on which a progress report is included in Section V of this Paper.

Fine cement passing the 120 I.M.M. sieve will cause erratic working of the feed device with consequent intermittent supply to the burner, while the coarser grains retained of the 60 I.M.M. sieve do not attain a sufficiently high temperature in passing through the flame. Damp material, irrespective of grain size, will not feed satisfactorily. Work is now proceeding with the use of water-washed cements subsequently dried. This procedure removes the very fine particles normally clinging to the larger grains and may give more satisfactory results and permit the use of finer powders.

Operation of the Spray Welding Process

After removal of scurf from the retort to be repaired, the combustion flues are put under producer gas pressure to render all leaks readily visible in the retort as flames of burning gas. The manhole cover in the extractor casting is removed, and the burner is inserted and raised to the level of the leak to be repaired. The gas is turned on and at once ignites at the burner head. The oxygen is then turned on and the flame aimed at the leak; finally the cement powder is admitted with the oxygen and the repair commenced.

It has been found by experiment that oxygen pressure immediately behind the nozzle should be about 15 lb. per sq.in. and gas pressure at the burner head about 0·6 in. w.g. to produce the requisite flame about 8 in. in length. Preliminary experiments will have shown what corresponding pressures are required at outlet oxygen cylinder, and at the gas connexion. For a 14-ft. burner of the dimensions previously indicated, these pressures are approximately 20 lb. per sq.in. and 4 in. w.g. respectively. The welding flame is impinged upon the retort wall at the leak with the burner head about 1 in. away from the retort face. The burner is moved away from the leak about every 2 min. to judge the progress of the repair by the diminution in size of the flame through the retort wall. After this flame has been completely obliterated welding is continued for a few minutes to increase the thickness of patch. A hole 1 sq.in. in area can be filled to a depth of about an inch in 10 to 15 min.

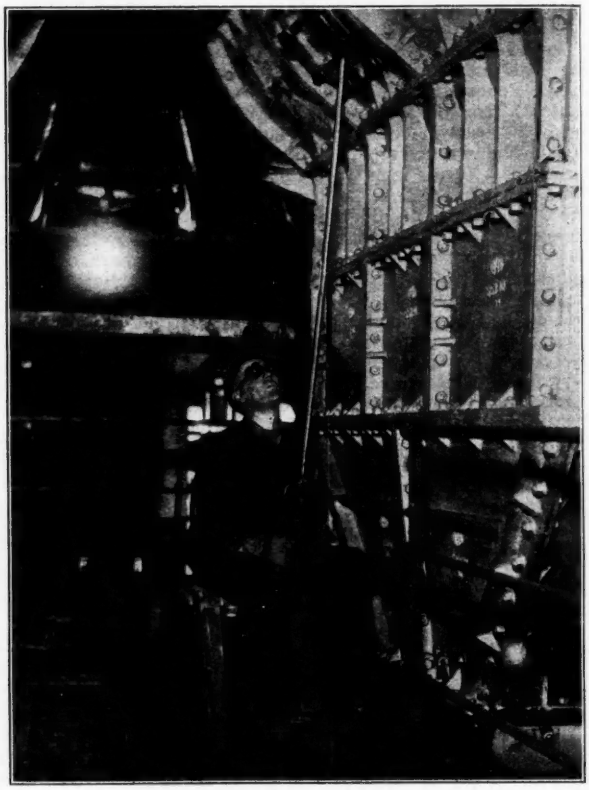

Figure 3.—*Burner in Operation.*

The weld sometimes projects slightly from the original retort face, but no instance has occurred of the travel of the charge being subsequently interfered with. When a repair is completed it is important that the powder feed should be cut off

before turning off the oxygen supply, as this completely clears the inner tube of powder and avoids settling with possible blockage or restarting.

Two men constitute a team for carrying out these repairs, each man taking his turn at operating the burner whilst the other manipulates the gas and oxygen valves from floor level. Owing to the heat between the retort bottom castings, the man operating the burner only works for spells of 10 min. at a time. An air-cooled shield made from light tin plate has been designed, and will shortly be tried. It is hoped so to improve the conditions that much longer spells of continuous working will be possible. After 10 min. work in a retort the burner head and part of the tube become red-hot, but no trouble has been experienced with softening or oxidation with the heat-resisting steel recommended. Figure 3 shows the burner in operation. The total weight the operator has to support is about 32 lb. Two men can readily repair 4 retorts, each showing 3 or 4 small leaks, in 8 hr.

There has been no opportunity, as yet, of inspecting cold a retort repaired by welding, but many examples of repair have been carried out on silica and firebricks in a muffle furnace. Some of the samples have shown cracks when cold, but no indication has been shown of cracks appearing while the bricks are still hot.

Costs of Retort Spray Welding

The Windsor Street Retort House has a maximum gas making capacity of 26 mill. cu.ft. per day. This make is maintained for four or five winter months, and is reduced to about 16 mill. cu.ft. per day during the midsummer period. The total number of retorts available is 242, with capacities of from 5 to 10 tons per retort per day.

Before the introduction of welding repairs, all retorts were sprayed after scaling, and repair by gun was carried out in addition where necessary. The staff for this work consisted of six men and a relief working on a six day rota in winter, and four men with a relief in summer. The wages cost amounted to £28 and £18 10s. per week, while cement cost £13 and £8 10s. per week, making totals of £41 and £27 per week in winter and summer respectively. The annual cost of hot repairs, including £560 for cement, was about £1,800, but the benefits obtained were very disappointing.

The welding method of repair has been used alone since last April, and has required two men with a relief, although it is expected that four men will be required in winter. During the summer months wages have amounted to £9 15s. and cement to about 14s. per week. Oxygen has cost 20s. and gas about 7s. per week. The total weekly summer cost is therefore about £11 16s., and the annual cost should not exceed £920.

The direct saving in labour and materials for hot repairs is therefore estimated at about £900 per annum, but a much greater ultimate saving due to longer retort life between cold repairs is expected. In this latter connexion it may be mentioned that a saving of only one penny per ton of coal carbonized on cold repairs and reconstructions would amount to about £1,600 per annum at Windsor Street.

Mr. Rhead presented the Paper.

Discussion.

Mr. A. T. Green (Director, B.R.R.A.): When Mr. Rhead invited me to open this discussion I felt it was a particular privilege because I have been impressed by the careful way in which this very difficult problem has been attacked. In the first place it is very clear to all of us that the idea of spraying retorts with a wet spray is not, shall I say, fundamentally sound, and apart from that, many of us have had rather sleepless nights with the consequences of such a procedure on silica refractories. Some years ago the British Refractories Research Association through its Joint Committee with The Institution of Gas Engineers was asked to consider this job, and I was also aware at the time that Mr. Rhead had previously had a shot at this so-called dry patching. Our job was essentially a laboratory job with all the limitations that one may expect in the circumstances. We saw sufficient to make us think that it was possible that a plant could be designed to patch a retort by a dry spray method. The principle is obviously correct but the difficulties are equally obviously very great. One of the difficulties is that the mixture that one must have must contain, or should contain, some material which fluxes earlier than the major body of the material, and in any circumstances any material you use will have some such constituent within it. There must, therefore, be a tendency, as far as we can see, for a material so fused on its passage to the retort surface or to the brick surface, to cause a quick adhesion of certain portions of the sprayed cement. If that occurs it tends to build a small stalactite, and that becomes of necessity hotter because it is nearer the flame, and, therefore, probably tends to increase in size. I would like to ask Mr. Rhead whether he can say that there is definitely an indication that in his procedure the ideas which we arrived at from our work are operating in the work that he is doing, because if that is so he is obviously getting a method of giving a smooth surface which takes us a long way towards patching the so-called flaked surface in the upper zone of the retort. It is further clear from what Mr. Rhead and his colleagues have shown from their admirable preliminary survey of the fundamentals upon which any such procedure must be based, that we are bound to have a certain amount of decomposition of some material within that cement resulting in a tendency to intumescence and the lack of the surface that we want to see with any such sprayed surface. Can Mr. Rhead tell us whether he has found that the presence of any material which will be best in the circumstances of his work will, at the same time, give rise to any serious defect of this character?

A Valuable Advance.

Mr. G. C. Pearson (Birmingham): This description of a satisfactory means of repair of holes and leakages in vertical retorts is a valuable advance in our Industry. Internal stresses due to physical causes are bound to induce minor leakages in retorts chiefly in the zone of greatest heat, and these are usually evidenced in the fracture or failure of the joints. The subsequent growth of small leaks proceeds rapidly, owing to the burning of coal gas emanating from the retorts, and is accelerated by the fluxing of the refractories by coal ash present in the flue gases.

With the introduction of upwardly heated vertical retorts the effects of leakage have become more serious than with the downwardly heated type. The zone of greatest heat is now at the bottom of the retort, and leaks in this vicinity are not protected by the formation of scale. The supply of secondary air for the combustion flues of upwardly heated retorts is immediately available in this zone to burn leakages of coal gas, whereas in the downwardly heated system such combustion tends to be stifled by an atmosphere of descending waste gases.

Further, in the upwardly heated system the flames issuing from leakages are travelling upwards and therefore meeting with little resistance. Top temperatures then tend to be unduly high for the firebrick construction at the top of the retort, and extensive checking of control tiles is necessary. The loss of heat balance resulting has an adverse effect on carbonizing efficiency far outweighing the loss sustained by the coal gas leakage.

Spalling of the silica in downwardly heated retorts is the determining factor influencing the life of the plant before the first cold repair. The great reduction in spalling that has accompanied the change in the method of heating, however, should enable us to obtain a life of an extra year or so with the upwardly heated type. The latter unfortunately are liable to become rapidly uneconomical for work owing to extensive leakage.

Our retort house practice has included repair to leakages at scaling times by the application of wet refractory material either sprayed or gunned into position. This type of repair has proved to be of a very temporary nature, and between each scaling time considerable extension of the leakages has taken place.

In our Department we have been faced with the necessity of cold repair to upwardly heated retorts after a working period of only eighteen months. Undertakings in the Midlands have had similar experiences, and in the absence of any system of repair as described by Messrs. Rhead, Hawthorn, and Deacon, the upwardly heated system would, in my opinion, necessarily lose favour despite its manifest advantages in other directions.

The method of welding described in the Paper may be said

to be in its early stages, but has already demonstrated its advantages. The third range of the upwardly heated type of vertical retort constructed in Birmingham was one of 56 retorts, 10½ in. major axis, laid down in 1936 and put to work in September of that year. After twelve months' work leakage had developed to such an extent that immediate repair had to be seriously considered, and arrangements were made to carry out this work in the summer of 1938. In January this year, however, welding experiments were commenced on a general scale and applied to this range in February. The practice was immediately attended with success, and the summer repair programme for the range was postponed. At the present time the work is in splendid condition and giving the optimum thermal results in the Department.

A further range of smaller upwardly heated retorts started to work in the autumn of 1937 developed incipient leakage early in 1938, and this range has been, by this repair system, so conserved that no leaks of any serious dimension have been allowed to develop.

I consider this welding system to be a most important advance in the technique of the maintenance of vertical retorts.

Peculiar Value of the Spray Welding Process.

Dr. E. W. SMITH (Woodall-Duckham Companies): I do not know why Mr. Knead asked me to speak to-day, whether it was from the point of view of pure sentiment and old associations, or whether it was to compliment the contractors who are responsible for the plants which have given such bad results! Nevertheless, I would like to remind Mr. Rhead that there are a good many of these plants in the country and that in the majority of cases where the instructions for wet spraying have been carried out faithfully from the beginning they are not experiencing the troubles he suggests at the end of twelve months. I do not know what experience Mr. Rhead has had in that respect, but I do feel that the tendency to-day is to believe that wet spraying has been a bad process. I agree with everybody that it is a system that one would not develop if there was anything else available which was the best that was known by all experimenters in repairs. The dry method has always appealed to all of us and most of us have been experimenting with it, and the congratulations that one would like to be fulsome about and which one cannot exaggerate should be made to Mr. Rhead and his colleagues. At the same time, it has never yet been shown, whatever our fears have been, that when properly applied wet spraying from the beginning has caused any trouble. On the other hand, there are quite a number of cases in which wet spraying has been completely ineffective for preventing leakages.

The Authors are to be congratulated for bringing to a practical stage an idea which has been in the mind, as acknowledged in the Paper, of some people for a number of years. Such an idea stands or falls on its practicability in the hands of semi-skilled workmen. I strongly agree with Mr. Rhead that it is absolutely essential to train men properly to work this process. Mr. Rhead asked me to see this method a week or two ago and one could not help feeling enthusiastic about the possibilities of the process. The fact that the process has been in general use on two of their installations for eight months shows that the Birmingham process of spray welding has attained this requirement of success. The Authors make it clear that their Paper is really a progress report. Although they hint at future possible uses, the immediate practical value of the process is that it provides a means of effecting hot repairs and thus preventing premature shut-down of a plant. An efficient method of effecting such hot repairs will be received with as great enthusiasm by plant constructors as it will be by plant operators.

One of the perpetual anxieties to the plant constructor is that after utilizing careful technique in design, the highest quality of materials for construction and the best workmanship and supervision he can obtain, premature leakage sometimes occurs in a few joints or local areas. This sometimes necessitates a cold repair at a time when the main bulk of the brickwork is in perfect condition. It is for the hot repair of such local areas that the Birmingham blowpipe spray welding process promises to be of such importance to the Industry as a whole.

The particular features of the process which impress themselves on the mind of the observer are, first, that there is a close bond between the patch and the brick, and, secondly, that a hole can gradually be filled by application of the blowpipe flame to the periphery of the hole without the need of any temporary backing of the hole, as is usually necessary in wet patching methods. The comments of Mr. Green on this question of the structure of the patch are very important. I can quite conceive—I may be wrong—that the edge of the hole itself is fused because the temperature that is used with the blowpipe with oxygen—I think Mr. Green usually works with a straight oxygen—is very high, and it is conceivable that the edges are fused and that there is complete adherence.

The data given on the relative costs of the spray welding process and normal wet methods make very interesting reading. It would be of great value to know whether the Authors have found that a joint repaired or a small hole filled remains tight over a series of scurfing cycles.

It is noted that during the summer period with a gas output of about 16 million cu.ft. per day on one works, two men per day with a relief are employed to carry out the spray welding process. It is also stated that two men can repair four retorts each with three or four small leaks per day. From this it would appear that on a 16 million cu.ft. per day output—which must involve quite a large number of retorts—some 12 or 16 small leaks are being repaired per day. It may be of interest to examine this problem of the incidence of retort leakages a little further. Following the Authors' argument that retort leakage is usually found in the hottest zone of the retort, and allowing this zone to be 8 ft. high, the number of joints in this area in continuous vertical retorts capable of making 16 million cu.ft. of gas per day, is approximately 72,000. Of these, about 5,000 are available at any time for examination, while the retorts are scurfing. Of these 5,000 joints about 14 appear to be attended to per day by the spray welding process, or less than 0·28 per cent. The conclusion one reaches from this calculation has already been expressed earlier in my remarks—viz., that a premature repair may be contemplated for reasons of purely local leakage, and herein lies the peculiar value of the spray welding process.

Limitations at the Moment.

The process depends for its success on accurate positioning on a local area, and is therefore the alternative to a cement gun. Really, there is not an alternative. There is only one process to use and once this is perfected the cement gun will never be used. Its limitations at the moment lie in attending to a large number of joints showing tendency to leakage which may be effectively and rapidly sealed by normal wet spraying methods.

The subject of alternative cements for spraying has been carefully studied by the Authors. The tentative recommendations rather lead one to the conclusion that providing the grading is correct and the cement is dry—although this is not emphasized in the recommendations—any of the established hot patching cements would serve in the spray welding process. One feels that this work has reached the stage that what is wanted is the accumulation of much more information by the general adoption on a number of works. This will reveal the answer to such questions as the effect in cooling down retorts which have been subjected to spray welding, what happens when welding is applied to silica bricks already heavily impregnated with fuel ash, and so on. In the meantime, the Industry is much indebted to the Authors and the Birmingham Gas Department for publishing the results of their work to the Industry with so little delay.

Finally, I would like to say that my Company would be delighted to collaborate with Birmingham in the development of this work; indeed, not only with Birmingham but with any others which Birmingham may care to call in, because I am quite sure that there is no subject of more interest or more value to the Industry at the present time. I think that this collaboration would be the best means of making progress.

Mr. M. S. GASKILL (West's Gas Improvement Company, Ltd.): Having had the privilege of seeing the method in operation at Birmingham, I can fully appreciate the amount of work which has been entailed to develop the process of repairing retorts under heat to its present successful stage. It may be of interest to outline very briefly a few points from our own work which, to a great extent, confirm the results obtained at Birmingham.

Following the Paper by Mr. A. T. Green, of the B.R.R.A., the first attempts were made with an air coal-gas flame, aluminium powder being used to obtain a localized high temperature. Subsequently, the oxy-coal-gas flame was used, the oxygen being employed as in the Birmingham apparatus for the conveying of the cement powder. The part of the apparatus inserted into the retort was enclosed in an air-cooled jacket. Such an arrangement has the disadvantage of increased weight, but it is believed that it might facilitate the introduction of a separate feed for the cement which, as Mr. Rhead has indicated in his Paper, would be advantageous. The difficulty of the increased weight of the apparatus could, of course, be overcome by suitable supporting arrangements.

In our earlier experiments a comparatively large oxy-coal-gas flame was used, and the amount of cement injected was approximately twice that suggested by Mr. Rhead. The results under these conditions were not satisfactory, and there appear to be definite limitations in this respect; in fact, we are of the opinion that it is doubtful if a larger single flame than that employed by Mr. Rhead is practicable. The use of a multi-jet burner, as suggested in the Paper, introduces a number of difficulties, and the development on this line is awaited with interest.

The grain size of the cement was found to be an important factor. As was the case at Birmingham, the most satisfactory grade was 60 to 120 I.M.M., but it is noted that when washed material is used the authors suggested the use of 100 to 200 I.M.M. It would be of interest to know if this finer material has been found in practice to have such advantages as to justify the washing and very thorough drying which would be essential.

With regard to the feeding device, an arrangement very similar to that shown in Figure 4 was found to be most satisfactory. The "wash-bottle" type of apparatus was discontinued since it had a tendency to cause separation of the flux.

With regard to the fluxes suggested in the Paper, it is noted that mica is included. It is understood that about six commercial varieties of mica are available. Perhaps Mr. Rhead would indicate whether he considers a mica containing an Na and/or K base, or one containing an Fe and/or Mg base most suitable.

The Authors raise the question of the effect of the rate of cooling on the adherence of the cement. It would be of interest to learn if any retorts which have been patched have been subsequently cooled down and restarted, and, if so, what was the result.

Vast Amount of Work.

Mr. E. Astbury (Liverpool): It was my privilege through the courtesy of Mr. A. W. Smith and Mr. Pearson to visit their works and see the process of welding retorts in operation and also some of the samples and experiments which have been carried out in the laboratory. In the Report, reference is made to test No. 231 and that gives some idea of the vast amount of work which has been carried out in order to bring the process to the position in which it is to-day. I was very much impressed by witnessing the patching of a retort. There were one or two rather large cracks through which flames were issuing some inches long into the retort and the operator seemed to have very little difficulty in welding up these joints and making the retort gas-tight.

There is one question I should like to ask Mr. Rhead, and that is, after a retort has been repaired and put to work, does he find when they come to scurf the retort that there is any oxidation of the crack or opening which has been welded, either on each side of the weld or in the neighbourhood of the weld.

Mr. G. E. Currier (Bradford): In December, 1937, a new bench of continuous vertical retorts was started up at our Birkshall Works, this installation being a part of the reconstruction and centralization of the manufacturing plant. The bench comprises thirty upwardly-heated retorts with a net productive capacity of 19½ million cu.ft. of 500 B.Th.U. gas per week. This plant has now been in operation for ten months and has worked very well; all the guaranteed results have been obtained comfortably and without the slightest forcing of the plant or any special supervision. The retorts are built of a high quality silica material, with the exception of the top and bottom, which are of fireclay material, and the maximum temperature we allow in the combustion chambers is 1,350° C.

The only matter which caused any concern was retort leakage, and to our surprise this showed itself during the time some of the retorts were empty for scurfing the first time. The leakage at any time has only been slight, with the exception of two retorts, and in these the leaks have never been serious. The worst leakage has been at the junction of the silica and fireclay material at the bottom of the retort, and there has been some leakage in the silica portion. The retorts have been sprayed from the bottom at the end of the scurfing operation with a slurry of refractory cement, and some of the leaks have been stopped or reduced with spraying, and others by means of the cement gun. It has been possible to control the leakage up to the present time, as is shown by the following gas analyses:

—		CO_2.	O_2.	N_2.	CO.	Total Inerts.
B.1 (New Bench)	June, per cent.	1·8	0·1	4·8	14·4	6·7
	July, per cent.	1·7	0·1	4·9	13·8	6·7
	Sept., per cent.	1·9	0·2	4·1	13·9	6·2
B.1 (New Bench) (worked 281 days) B.2 (worked 1,783 „) A.2 (worked 603 „)	Sept., per cent.	1·9	0·3	6·0	13·2	8·2

The coal carbonized to Sept. 30, 1938, was 49,525 tons and the cost of spraying the retorts and stopping leakages amounted to £162 10s., equivalent to 0·79d. per ton of coal carbonized. It has always been realized that these methods of dealing with retort leakage are fundamentally wrong, and I was delighted to be informed by Mr. G. C. Pearson, Chief Engineer of the Birmingham Gas Department, of the new dry process which had been evolved by the Authors of this Paper. I was then privileged to see the process in operation at the Windsor Street Gas-Works, and it is evident that this process will entirely supersede the old wet methods. The idea of a dry method was first suggested by Mr. T. F. E. Rhead some few years ago, and the Authors, as a result of a tremendous amount of experimental work, have successfully developed an appliance for its practical application.

It is generally understood that the life of a vertical retort setting is reduced by 100 to 200 days by each cold shut-down, and by the use of this process the period between shut-downs will be extended and, therefore, the ultimate life of the retorts increased. The Authors recognize that finality has not been reached, and no doubt improvements will be made, for example, in increasing the rate of deposition of the fluxing cement. The uses of the process will doubtless be extended far beyond retort leakage, as is indicated by the Authors, and a further suggestion is to consider the possibility of spraying refractory materials to give a thin coating of a special refractory during manufacture. The cost of carborundum has so far prohibited its use in retort work, but if it can be used as a thin coating, it may be a commercial proposition and would greatly increase the life of retorts, although it is recognized that the difference in coefficient of expansion of carborundum and the usual retort materials may present practical difficulties. The cost of retort repairs is always an important item in the balance sheet, and any process which will reduce this cost will be welcomed by all concerned.

The Authors are to be warmly congratulated on their success in developing this process, and the Birmingham Corporation Gas Department deserve our best thanks for placing the results of this research work before the Gas Industry.

This closed the discussion on the Paper.

Interim Report of the Sub-Committee on Unaccounted-for Gas

[ABSTRACT]

Communication No. 194

Arising from the presentation and discussion of a Paper on "Gas Unaccounted-for", by R. H. Ruthven, at a meeting of the Southern Association of Gas Engineers and Managers (Eastern District) on 18th February, 1937, the Association recommended "that a Committee of The Institution of Gas Engineers be set up to enquire into the possibility of arriving at a formula—sufficiently accurate for practical purposes—to enable Gas Undertakings to reduce to comparable conditions of temperature and pressure gas made as registered by station meter and gas sold as measured by consumers' meters."

The Council of the Institution referred the matter for consideration to its Research Executive Committee, which appointed for the purpose a Sub-Committee on Unaccounted-for Gas.

The membership of the Sub-Committee is as follows:

H. Hollings, D.Sc. (*Chairman*); J. E. Davis; E. J. K. Fussell; Stephen Lacey, B.Sc., M.Inst.C.E.; T. F. E. Rhead, M.Sc., F.I.C.; R. H. Ruthven.

SUMMARY

It was felt at the outset that in any investigation of the question of unaccounted-for gas, the first step was to secure an agreed basis upon which it may be calculated. At the present time there is no uniform method of calculation of gas quantities in the Gas Industry. Accordingly, a recommended method of calculation of gas quantities was prepared and is given in the Report.

As a preliminary to this publication, it was decided to ask a limited number of Gas Undertakings, known to be interested in the matter, to submit to the Committee their results on this uniform basis.

The Recommended Method was submitted to the following Undertakings, the selection being influenced by such factors as geographical situation, in order that the results might be reasonably representative:

Birmingham Corporation Gas Department.
Bristol Gas Company.
Cardiff Gas Light and Coke Company.
Edinburgh Corporation Gas Department.
The Gas Light and Coke Company.
Newcastle-upon-Tyne and Gateshead Gas Company.
British Gas Light Company, Limited, Norwich.
Ramsgate Corporation Gas Department.
South Metropolitan Gas Company.
Tottenham and District Gas Company.

TABLE 1.—*Annual Percentage of Gas Unaccounted-for*

Year.	Undertaking.									
	A	B	C	D	E	F	G	H	K	L
1	2	3	4	5	6	7	8	9	10	11
1925 ..	5·03	3·18								
1926 ..	3·85	2·27								
1927 ..	4·39	2·43								
1928 ..	4·24	2·38	2·23	6·63	6·63					
1929 ..	3·91	1·59	2·74	7·39	3·88					
1930 ..	4·04	1·06	2·17	7·23	4·59					
1931 ..	3·67	1·40	1·59	7·89	3·94					
1932 ..	4·23	1·09	1·93	7·26	3·72	3·65	6·9			
1933 ..	4·32	1·08	0·97	7·45	5·46	3·46	7·3	6·56		
1934 ..	4·37	0·56	2·06	6·82	5·33	3·56	7·6	6·56		
1935 ..	3·98	0·35	2·05	6·06	6·92	3·50	8·2	7·16		
1936 ..	4·32	0·31	1·17	5·69	5·17	3·90	8·7	7·09	7·94	
1937 ..	3·69	0·79	2·45	4·97	5·27	3·07		7·01	8·48	3·05

The results received from these Undertakings are given in the above table, and it is immediately evident that not only are there big differences as between various Undertakings, but in most cases "unaccounted-for gas" represents a serious loss of revenue which, it is suggested, will be well worth investigating further.

The Committee has therefore prepared a statement of the various factors which may influence the extent of the gas unaccounted-for, and it is proposed to continue the investigation into a selection of those factors which are considered to have a major influence.

RECOMMENDED METHOD OF CALCULATION OF GAS QUANTITIES

If the records of the Undertaking are on a volume basis, the volume of gas unaccounted-for shall be given as a percentage of the volume of gas made, all volumes being corrected to standard conditions of temperature (60° F.), pressure (30 in. mercury) and humidity (dew point 60° F.).

If the records are on a therm basis, the therms unaccounted-for shall be given as a percentage of the therms made, and, in view of the effects of gas drying, it must be noted that it is possible to multiply gaseous volumes by calorific values to give true therms only if both are reduced to the same conditions of temperature, pressure and humidity.

A. Gas Made at Works

The temperature of the station meters is obtained by means of thermometers suitably placed, and the pressure* is obtained from readings of the barometer at the Works to which is added, in inches of mercury, the equivalent of the excess gas pressure. No temperature, altitude or latitude corrections are made to the barometer readings, but the barometer should be maintained at a temperature between 55° and 65° F. as prescribed in the Gas Referees' Notification.

If the station meter is of the ordinary drum-type, water-sealed, or if determinations of the humidity of the gas show it to be saturated with water vapour at the temperature of measurement, the volume which the gas would occupy at 60° F., 30 in. pressure, and dew point 60° F., is computed daily by means of Tabular Numbers [given in an Appendix].

The number of therms made is determined from the corrected volume of gas by multiplying it by the average calorific value as ascertained by the Gas Examiner, or, where such is not available, by some other suitable average.

If benzole recovery is practised at a point preceding the station meters, the volume or therm equivalent of the benzole is added to the quantity of gas made as calculated above. 1 gal. of crude benzole may be taken to be equivalent to 40 cu.ft. of benzole vapour at 60° F., 30 in. pressure and dew point 60° F., or to 1·4 therms in the case of oil-recovered benzole, and to 45 cu.ft. or 1·6 therms in the case of carbon-recovered benzole. This step, however, should be omitted if it is decided to omit from the statement of gas sold the equivalent of the benzole.

If benzole recovery is practised at a point following the station meters, the volume equivalent of the benzole is subtracted from the corrected volume of gas before this is multiplied by the average calorific value in the determination of the number of therms made. The volume equivalent is indicated in the preceding paragraph. In this case the addition of the thermal equivalent of the benzole to the gas made will depend upon whether or not the thermal equivalent of the benzole is added to the gas sold (see B. (3)).

B. Gas Sold

(1) *Quantity of Gas Passing through Consumers' Meters*

The volume of gas passing through consumers' meters may be calculated from the total of the consumers' meter readings or from the amount of money obtained for gas sold at each of the prices charged for gas. Suitable adjustments should

*Alternatively, the gas pressure may be obtained by means of a barometer which is connected to the gas at the meter inlet instead of being left open to the atmosphere. In this case, of course, no further addition is necessary in respect of the gas pressure.

be made in respect of bad debts, meters broken open, and other estimated volumes for public lighting, water heating, etc.

TABLE 2.—*Computation of Temperature of Gas Ruling at Consumers' Meters*

Average Shade Temperature, ° F.	Correction, ° F.
Below 40·1	Pro rata
40·1 to 42·5	Add 6
42·6 ,, 45·0	,, 5
45·1 ,, 47·5	,, 4
47·6 ,, 50·0	,, 3
50·1 ,, 52·5	,, 2
52·6 ,, 55·0	,, 1
55·1 ,, 57·5	No correction
57·6 ,, 60·0	Deduct 1
60·1 ,, 62·5	,, 2
62·6 ,, 65·0	,, 3
65·1 ,, 67·5	,, 4
67·6 ,, 70·0	,, 5
Above 70·0	Pro rata

The volume so obtained is corrected for temperature, pressure, etc., as follows:

(*a*) *Temperature.*—In the following empirical estimate of gas temperature it is assumed that correction is made for the average local temperature of consumers' meters and at the same time for the circumstance that different quantities of gas may pass at different times of the day. The average weekly temperature of the atmosphere is taken as the arithmetic average of the daily temperature. The daily temperature is taken as the arithmetic average of the maximum and minimum shade temperatures for the day at some point within the area of the Undertaking. It may be convenient to make use of the weather reports issued by the Air Ministry or to make observations at the office of the Undertaking. The temperature of the gas ruling at the consumers' meters is computed weekly from Table 2, prepared in accordance with a recommendation contained in a report of the Incorporated Institution of Gas Engineers:*

(*b*) *Pressure.*—The daily barometric pressures† may be taken from a barometer at the Works or office of the Undertaking and the average pressure is calculated each week. For this purpose an average of daily spot readings is sufficiently accurate.

If there is any difference between the altitude of the barometer and the average altitude of consumers' meters an appropriate correction should be made to the weekly average, *i.e.*, for each 10 ft. excess altitude of the consumers' meters subtract 0·01 in.

To the corrected barometer reading an addition is made in respect of the gas pressure at the consumers' meters. For example, this pressure may be 4 in. of water, in which case an addition of 0·30 in. of mercury is made to the barometer reading. If any different value is used the fact should be noted.

(*c*) *Volume Correction Factors.*—Using the temperature and pressure obtained as in (*a*) and (*b*), the volume correction to be applied to the gas passing through consumers' meters to correct to standard conditions is taken weekly from Appendix 1‡ if the gas drying process is not in use. In arriving at the quarterly correction factor it is preferable to take an average of the weekly factors, weighted according to the quantity of gas delivered weekly from the Works.

If the gas passing through the consumers' meters has been dried, the further provisions of Appendix 2 apply.

The number of "reputed therms" sold, as shown in the records of the Undertaking, is corrected for temperature and pressure by multiplying by the Volume Correction Factor obtained as already described. The figure so obtained is further corrected for excess calorific value by multiplying it by a correction factor obtained by dividing the calorific value ascertained by the Gas Examiner by the declared value.

If the gas passing through the consumers' meters has been dried, the further provisions of Appendix 2 apply.

(2) *Gas Used on Works*

The volume of gas used on the Works is multiplied by the same factor as that used for correcting the gas sold to consumers, and also by the same calorific value in order to compute the therms used on the Works. The corrected volume or therms so obtained is shown as a separate item in the gas accounted-for.

(3) *Gas Sold in the Form of Benzole*

Where benzole recovery is practised, the volume or therm equivalent of the benzole is added to the quantity of gas sold, and is shown separately as an item styled "Sundry Processes".

Where the benzole recovered is not included in the volume of gas made it should be excluded from any calculation of gas sold and from any calculation of unaccounted-for gas.

C. GAS UNACCOUNTED-FOR

The sum of the corrected volumes or of the therms obtained in (1), (2) and (3) is subtracted from the corrected volume or therms made, in order to obtain the gas unaccounted-for, and the figure so obtained is expressed as a percentage of the gas made. A typical calculation is worked out in detail in Appendix 4.

FACTORS INFLUENCING GAS UNACCOUNTED-FOR

STATION METERS

The accuracy of the drum type of station meter is influenced by the method of proving, frequency of examination and the method of maintaining the water level.

In most meters the gauge indicates the level of water inside the tank, and it is necessary to ensure that this is the same as the level inside the drum, for it is only when there is this equality of levels that the capacity of the meter is independent of the speed of rotation and consequent back pressure.

It is highly desirable that station meters should be proved not less frequently than once a year and that whenever any error is revealed by the proving, the meter should be overhauled by some competent person.

The accuracy of the reduction of the recorded volume to standard conditions depends upon the accuracy of the thermometer and barometer, and upon the positioning of the thermometer.

In the case of one Undertaking, the temperature at which the gas is measured in the drum is assumed to be the same as that of the water in the drum, and the thermometer is placed just under the water level at the outlet end of the meter. The thermometer bulb is made to come into actual contact with the water, while the thermometers are certified as being correct within ±0·5° F. and inspected periodically.

Where it is not practicable to insert the thermometer into the meter water, a sufficiently accurate figure may be obtained if the thermometer is inserted through the front of the meter casing above the water line in such a position that its bare bulb is exposed to the gas as it issues from the drum.

In the case of other types of meter, similar factors will influence the accuracy, together with other items such as slip in the case of Connersville meters and specific gravity in the case of orifice meters.

CONSUMERS' METERS

The accuracy of the proving and setting of consumers' meters is obviously of importance and the Committee has been much impressed by the apparatus designed by Major C. G. Hyde. It was devised particularly for the proving of

* *Trans. Inc. Inst. Gas Eng.*, 1898, VIII, 42.

† Alternatively, the pressure may be obtained from published barometer readings for the locality. Published barometer readings are corrected for altitude, latitude and temperature before publication, and are thus not comparable with the barometer readings used in the determination of the calorific values. The following adjustments are therefore made:

1. An addition of 0·79 in. is made to correct to 60° F. (the temperature at which the barometer is read for calorific value determinations).
2. A deduction is made to correct for the average altitude of consumers' meters in the area of the Undertaking. In London the altitude is assumed to be 70 ft., and the corresponding deduction from the barometric reading is 0·08 in. The deduction made by each Undertaking should be noted.
3. A deduction is made to correct for the latitude of the Undertaking. In London this amounts to 0·016 in.

‡ Omitted from our Abstract.

meters used in connexion with calorimeters, but attention is called therein to the fact that this apparatus could be utilized for the proving of secondary standards used for the proving of consumers' meters.

The early discovery of meters which have become inaccurate in use is obviously of importance, and any system of spot testing for accuracy of consumers' meters which results in the exchange of those found to be defective must have an influence upon the gas unaccounted-for. A defect having a major influence on gas unaccounted-for is the passing of unregistered gas at low rates, and it is particularly important where a gas installation includes one or more appliances with continuously-burning pilots. Meters passing unregistered gas when in use on consumers' premises may be discovered by observing whether or not a meter registers when the consumption is confined to a pilot burner, where such exists, or by the temporary insertion, on the outlet of the meter, of a device including a pilot burner of a predetermined gas rate.

The accuracy of the correction of gas sold is dependent upon the accuracy of the temperature, pressure and humidity assumptions for the gas passing consumers' meters. Any change in the general position of meters on consumers' premises may affect the relation between the meter temperature and atmospheric temperature, necessitating revision of Table 2. This table of relationships between meter temperatures and atmospheric temperatures has been adopted somewhat arbitrarily. It is fully recognized that it may need amendment in the light of experience. It will certainly need amendment if and when a better criterion of atmospheric temperature can be secured and it may be that ultimately different tables should be adopted for different geographical areas. However, pending the accumulation of more experience it is hoped that all Undertakings will adhere to this table in order to avoid confusion. Any error in the table will have a relatively slight effect upon the final gas unaccounted-for.

Leakage

From the foregoing it will be appreciated that in many cases direct leakage of gas represents a very small proportion of the total gas unaccounted-for. S. Lacey* has described certain large-scale tests carried out in London which led him to the conclusion that leakages from all sources amounted to less than 1 per cent. of the gas made.

Leakage from gasholders may be unsuspected owing to the difficulty of testing for it. More frequent examination of holders in the manner recommended by the Gasholder Committee† of The Institution of Gas Engineers should have beneficial results. Apart from perforations of the crown and side sheeting and leaky joints, the possibility of blowing when the holder cups must not be ignored.

Condensation of oil in mains will be recorded as gas unaccounted-for, but is always very small.

All gas used or sold under contract by the Undertaking and not measured should be brought to account in the calculation of the gas unaccounted-for. Attention should be paid to the proper estimation of gas used on the Works for lighting and testing purposes, and used for street lighting. In the latter case, errors of estimation may occur because of pilot consumption, over-gassing of lamps, pressure variations, failure of automatic cutting-out, delay in adjusting clock-controllers to changing lighting hours, and the like.

INFLUENCE OF THE GAS DRYING PROCESS UPON GAS QUANTITIES

For the purpose of demonstrating the effect of the gas drying process upon the calculation of gas quantities, the following average conditions have been assumed:

The gas made is measured at, or corrected to, 60° F., 30 in. pressure, and dew point 60° F.

The gas sold is measured at 54° F., 30·27 in. pressure (including gas pressure) and a dew point of

50° F. if there is no gas dehydration process,
37° F. if there is a gas dehydration process.

For every 100 cu.ft. supplied to the consumer,

5 cu.ft. are lost by leakage and unregistered gas,
1·2 cu.ft. are used on the Works.

The calorific value of the gas made is

500 B.Th.U. if there is no gas dehydration process,
495 B.Th.U. if there is a gas dehydration process (brought to the declared calorific value by the dew point allowance).

If the effects of alterations in the humidity are separated from those of temperature and pressure as in the following statements the bearing of the gas drying process upon the calculation of gas quantities may be appreciated more clearly.

(i) *Effect upon Volume*

Without gas drying, for every 100 cu.ft. supplied to the consumer,

1·2	cu.ft. are used on the Works;
0·6	cu.ft. are condensed as water in the mains to reduce the dew point to 50° F.;
2·2	cu.ft. are lost due to the contraction of volume to reduce the temperature to 54° F. and to increase the pressure to 30·27 in.;
5·0	cu.ft. are lost by leakage and unregistered gas;
100·0	cu.ft. are sold to the consumer;
109·0	cu.ft. must be made at the Works.

With a gas drying process in operation, for every 100 cu.ft. supplied to the consumer,

1·2	cu.ft. are used on the Works;
1·1	cu.ft. are removed as water vapour in the drying plant to reduce the dew point to 37° F.;
0·0	cu.ft. are condensed in the mains;
2·2	cu.ft. are lost due to the contraction of volume to reduce the temperature to 54° F. and to increase the pressure to 30·27 in.;
5·0	cu.ft. are lost by leakage and unregistered gas;
100·0	cu.ft. are sold to the consumer;
109·5	cu.ft. must be made at the Works.

(ii) *Effect upon Therms*

In the following the calorific values referred to are heating values per cu.ft. of the gas as measured not reduced to 60° F., 30 in., and dew point 60°.

Without gas drying for every 100 therms paid for by the consumer,

1·2	therms are used on the Works;
0·0	therms are lost by condensation of water in the mains, but the calorific value is increased to 502·7 B.Th.U. by reason of the contraction of volume;
0·0	therms are lost by the contraction of volume in the mains due to the lowering of the temperature and increase of pressure, but the calorific value is increased thereby to 513·2 B.Th.U.;
5·13	therms are lost by leakage and unregistered gas;
2·64	therms are given to the consumer, by reason of the fact that the calorific value of the gas he receives is 513·2 B.Th.U.;
100·0	therms are paid for by the consumer;
108·97	therms must be made at the Works (calorific value, 500 B.Th.U.).

With a gas drying process in operation,

1·2	therms are used on the Works;
0·0	therms are lost in the drying plant, but the calorific value is increased to 500 B.Th.U. by reason of the contraction of volume;
0·0	therms are lost by condensation of water in the mains, as none occurs, and the calorific value is unchanged;

* *Gas J.* 1918, **144**, 118.

† See 3rd and 4th Reports of the Gasholder Committee, *Inst. Gas Eng. Comm. Nos.* 144 and 171.

0·0 therms are lost by the contraction of volume occurring in the mains due to the lowering of the temperature and increase of pressure, but the calorific value is increased to 510·5 B.Th.U. by reason of the contraction of volume;
5·10 therms are lost by leakage and unregistered gas: (this figure is slightly lower since the gas which is lost has a slightly lower calorific value);
2·10 therms are given to the consumer by reason of the fact that the calorific value of the gas he receives is 510·5 B.Th.U.;
100·0 therms are paid for by the consumer;
108·40 therms must be made at the Works (calorific value, 495 B.Th.U.).

APPENDIX 2

MODIFICATIONS TO RECOMMENDED METHOD OF CALCULATION WHEN GAS DRYING IS PRACTISED

Gas Made at Works

Where the gas as measured is not saturated at the temperature of measurement, the dew point of the gas is determined and the correction to 60° F., 30 in. pressure and dew point 60° F. is made by means of the formula:

$$\frac{17{\cdot}617\,(h - a^1)}{(459{\cdot}4 + t)}$$

in which a^1 is the actual vapour pressure in the gas as measured (*i.e.*, at the temperature of the dew point).

In practice, an addition of $(a - a^1)$ is made to the barometer reading before extracting the Tabular Number in the ordinary way. Values of $(a - a^1)$ corresponding to various meter temperatures and dew points are given in Appendix 3 [omitted from our Abstract].

Where the Gas Referees have prescribed special methods of testing partially dried gas deduction is made from the calorific value as ascertained by the Gas Examiner before calculating the number of therms made, because the official calorific value is that of 1 cu.ft. measured at 60° F., 30 in. pressure, and with the actual degree of saturation with water vapour. It is convenient to assume that throughout the year the average degree of saturation corresponds to a dew point of 37° F., in which case the correct deduction from the calorific value as ascertained by the Gas Examiner is 1 per cent. (If in the area of any Undertaking making a return the average dew point differs from 37° F. and any different deduction from the calorific value is made, the fact should be noted).

Gas Sold

If the gas has been dried, it will not be saturated at the calculated temperature of measurement. An addition to the barometer reading, corresponding to the average dew point as determined by the Gas Examiner, and ascertained from Appendix 3, is made before extracting the Tabular Number in the ordinary way. It is convenient to assume that throughout the year the dew point is 37° F., but if in the area of any Undertaking making a return the average dew point differs from 37° F., the fact should be noted.

In correcting the "reputed therms" the same modified Tabular Number is used, and in ascertaining the correction factor for excess calorific value, the same figure of 1 per cent. (or other percentage if the dew point differs from 37° F.) as was used in ascertaining the therms made, is deducted from the Gas Examiner's average calorific value before dividing by the declared value. Thus the factor will often be less than unity.

It will be appreciated that by this method all volumes are corrected to the standard conditions of 60° F., 30 in. pressure, and dew point 60° F., and that the calorific values used are also reduced to the same standard conditions.

If the gas is unintentionally partly dried, *e.g.*, by condensation in high pressure feeder mains, the loss will be included in the gas unaccounted-for.

APPENDIX 4

TYPICAL CALCULATION OF GAS UNACCOUNTED-FOR

(*e.g.*, December Quarter, 1937)

1. GAS MADE AT WORKS

—	Gas Metered by Station Meters. Thousand Cu.Ft.	Meter Temperature, ° F.	Barometer, In.	Meter Pressure, In. W.G.	Dew Point. (a)	Corrected Barometer, In.	Tabular Number.	Gas Made (Corrected). Thousand Cu.Ft.
1	2	3	4	5	6	7	8	9
Oct. 1	16,156	56	30·14	9·6	42	31·03	1·045	16,883
2	16,232	57	30·52	9·6	42	31·41	1·055	17,125
	etc.							etc.

Gas made (corrected) for quarter	1,606,860
Benzole recovered by oil-washing plant preceding station meters, 271,600 gal. × 40 (b)	10,864 (c)
Total gas made (corrected) for quarter (d)	1,617,724
Calorific value for quarter (as ascertained by Gas Examiner), B.Th.U., 503·5, *less* 1 per cent. dew point allowance (e)	498·5
Therms made (excluding benzole), 1,606,860 × 498·5 ÷ 100	8,010,195
Therms made in the form of benzole, 271,600 × 1·4 (b)	380,240
Total therms made during quarter	8,390,435

2. GAS SOLD AND USED

*Calculation of Weekly Correction Factor**

(1) Temperature, ° F.

Oct. 1	Max. 60	Min. 49	Average for week 55·0°
2	64	50	Adjusted „ „ (55·0° + 1·0°) = 56·0°
3	60	51	
4	58	52	
5	56	52	
6	61	51	
7	61	45	

(2) Pressure, In.

Oct. 1	Published barometer	30·14	Average published barometer, 30·25	
2		30·52	Add 0·09 for temperature ;	
3		30·42	Deduct 0·08 for 70 ft. altitude ;	
4		30·27	Deduct 0·02 for latitude ;	
5		30·01	Add 0·30 for 4 in. water pressure ;	
6		30·01	Average consumer's barometer	30·54
7		30·34	Correction for dew point 37° (f)	0·23
				30·77

Correction Factor for week ending Oct. 7 (56·0° and 30·77 in.) = 1·036

Calculation of Weighted Quarterly Factor

Week Ending—	Correction Factor.	Gas Delivered.	Product.
Oct. 7	1·036	97,601	101,115
14	etc.	etc.	etc.
	Total gas delivered	1,577,702	1,637,713
	Average quarterly factor	1·038	

* The odd days at the beginning and at the end of a quarter are averaged and dealt with as though they were separate weeks.

TYPICAL CALCULATION OF GAS UNACCOUNTED-FOR

3. GAS UNACCOUNTED-FOR

Gas passing consumers' meters (adjusted for bad debts, meters broken open, and other estimated volumes), thousand cu.ft.	1,476,706	Corrected for temperature and pressure (factor 1·038)	1,532,821
Gas used on Works, thousand cu.ft.	55,281	Corrected for temperature and pressure (factor 1·038)	57,381
Gas sold as benzole	271,600 gal. × 40 (b)		10,864
		Gas accounted-for	1,601,066

Volume percentage gas unaccounted-for $\frac{1{,}617{,}724 - 1{,}601{,}066}{1{,}617{,}724} \times 100 = 1{\cdot}0$ per cent.

Reputed therms passing consumers' meters, 1,476,706 × 500 ÷ 100	7,383,530	
Corrected for temperature and pressure (factor 1·038)	7,664,104	
Corrected for excess calorific value (× 498·5 ÷ 500) (g)		7,641,112
Gas used on Works, 57,381 × 498·5 ÷ 100		286,044
Therms sold as benzole, 271,600 gal. × 1·4 (b)		380,240
Therms accounted-for		8,307,396

Thermal percentage gas unaccounted-for $\frac{8{,}390{,}435 - 8{,}307{,}396}{8{,}390{,}435} \times 100 = 1{\cdot}0$ per cent.

Notes:
(a) This correction is omitted if the gas is saturated at the temperature of measurement.
(b) If the benzole is recovered in a carbon plant, these figures will be 45 and 1·6 respectively.
(c) If the benzole is recovered after the station meter, this volume is subtracted.
(d) If the records are on a volume basis, no further calculations are made to this figure.
(e) If there is no gas dehydration process in operation, this deduction is omitted, and if the average dew point as determined by the gas examiner is materially different from 37° F. the correct percentage dew point allowance should be used and noted.
(f) Similarly, if there is no gas dehydration process in operation, the correction to the average consumers' barometric reading is omitted.
(g) Similarly, if there is no gas dehydration process in operation, there is no deduction from the Gas Examiner's average calorific value before ascertaining this correction.

Dr. H. HOLLINGS (Chairman of the Sub-Committee) introduced the Report.

Discussion.

Mr. R. H. RUTHVEN (Ramsgate): In the Paper referred to in the introduction I mentioned that as long ago as 1896 the late Sir George Livesey read a Paper entitled "The Measurement of Gas in Relation to Temperature." He suggested that the Institution should undertake the work of making an authoritative declaration on the method for correction of gas to standard conditions, so that it would seem that our present discussion is some 42 years overdue.

I think we can assume that the desirability of having a standard method is acknowledged and it is very difficult to understand why the matter was not settled long ago. It cannot be that the question of gas unaccounted-for is of such small moment that it did not merit attention. One would be reluctant to suggest that we have been apathetic about the matter and it would seem, therefore, that it has been the difficulty of arriving at an acceptable formula which has prevented all gas undertakings showing gas unaccounted-for calculated to a standard basis. We may have to agree that a formula based on precise scientific facts is not possible, but I think it can be said that the Committee hopes that the basis as presented in this Report is a compromise which will give results sufficiently accurate for our purpose and may be adopted as standard practice.

From the particulars given in Table 1, wide differences in gas unaccounted-for are shown. For 1937, the lowest figure is 0·79 per cent., and the highest 8·48 per cent.—a difference of 7·69 per cent. The Report states that gas unaccounted-for in most cases represents a serious loss of revenue, which, it is suggested, should be well worth while investigating further.

I have felt for a long time that in the absence of a standard method of calculation, one had no criterion as to what were the *actual* unaccounted-for figures, and unless one had such a standard it was at least very difficult to assess the saving in net cost of gas that might be effected, what the loss of revenue was, and to what extent it was worth while spending money in order to save it.

Is it too much to hope that gas undertakings generally will accept the formula, and in the course of a year or two we may then know that all analyses will show all gas figures corrected to a common basis?

All Should Follow the Recommendations.

Mr. STEPHEN LACEY (Gas Light and Coke Company): There must be many of us in the Gas Industry who have been trying for years, on and off, to give a satisfactory account of gas unaccounted-for in our own undertakings, and it really is time that we put our heads together to solve the various problems that are involved, once and for all. For that reason I was very willing to become a member of this Committee, and am glad to take this opportunity of supporting Dr. Hollings' plea that all gas undertakings, or at least all those of a considerable size, should follow the recommendations in regard to the correction for difference in conditions of measurement of gas made on the one hand, and gas used on the other.

As Dr. Hollings has said, the Committee fully recognizes that the assumptions made with regard to the relation between shade temperature in the open air and the average temperature at which gas sold is measured are open to question, but, if we were to wait for sufficient information to establish a universal correction formula, we might wait until doomsday. And therefore, as the purpose of the correction is to clear the way for the investigation of questions of really practical significance, the sensible thing is to accept the recommended formula provisionally, and be prepared to modify it if and when further investigation provides the justification.

The importance of adopting a common method of correction is well illustrated by an examination of the figures of what may be called the true unaccounted-for gas in the Interim Report before the Meeting. The anomalies revealed in this table must certainly lead to investigations designed to explain the remarkable difference in gas unaccounted-for as between one gas undertaking and another. And while it would be premature to carry this discussion much beyond the question of establishing the recommended method of calculation of gas quantities, I am tempted to say a few words, if I may, about the review my Company is making in regard to accuracy of registration of consumers' meters under actual working conditions.

For the last ten years our gas unaccounted-for, after correction on the recommended basis, has been in the neighbourhood of 4 per cent. with no definite trend either up or down, and of this 4 per cent. inaccuracy of registration by consumers' meters is responsible for about one-half—that is, to the best of our knowledge at the present time.

In order to obtain statistical evidence which will provide a broad and reliable basis of fact for our investigation, we are now testing the whole of the meters returned from the district, whether the meters are exchanged for defects or are returned for such reasons as change of tenancy and demolition of premises. The results of the tests are being classified in terms of meter maker, type, size, age, reason for return, etc.

Out of this question have arisen two very relevant questions that up to the present have not, so far as I know, been given the close attention they deserve, especially in view of the increasing number of appliances in use with continuously burning pilots. I have in mind (1) the question as to what are the limits of accuracy and the suitability of the established methods of meter proving—especially at low rates of gas flow, and (2) the question of what proportion of the gas consumed by different combinations of gas appliances is used at rates very much below the nominal capacity of the meter installed.

With regard to (1) I will content myself by saying that our investigations show that the technique of proving meters is open to substantial improvement, both as regards accuracy and speed of operation. And further that an essential element of such improvement is the establishment of a more accurate proving standard than the ordinary test holder. In this respect consultation with Major Hyde will prove to be of great assistance.

With regard to (2) we have been obtaining direct information by connecting in series with meters on consumers' premises special meters equipped with devices which record the variation of consumption with time. This investigation is as yet only in a preliminary stage, but, even so, has yielded some very interesting information. It has certainly shown that the proportion of gas used at rates low in relation to the nominal capacity of the meter installed is much larger than is generally supposed, but more information is required before coming to definite conclusions. I am confident, however, that I shall shortly be able to place before the Committee results of our investigation, which will be of assistance to the further work of the Committee, and I suggest that others who may be working on the same lines should do the same.

A Quarrel with the Title.

Mr. B. R. PARKINSON (London): Dr. Hollings has very courteously invited my comments on the Report; as a result of which I have been able to discuss with him some textual criticisms and to receive elucidation, and these are details over which it is not necessary to take up the time of the members in General Meeting.

At the outset I am inclined to quarrel with the title "Unaccounted-for Gas," but that originated with the Paper read by Mr. R. H. Ruthven before the Southern District Association (Eastern Section) in 1936. Mr. Ruthven, however, confined himself strictly to one branch of the subject—viz., the correction of gas quantities for temperature, pressure, &c.—and it would appear from the preface that this was the special remit of the Committee whose report is before us: "to enable Gas Undertakings to reduce to comparable conditions of temperature and pressure gas made as registered by station meter, and gas sold as measured by consumers' meters."

I would deprecate embarking on the wider subject in any *de novo* sense, considering that there was a Committee of the Institution, meeting under another name, which sat for 9 years. Certain important branches of the subject were then dealt with in considerable detail, and the findings may not be out-of-date 15 years later. These did not specially include the computation of gas quantities which would, in any case, need to be brought up-to-date in the light of modern gas

practice. We may, therefore, welcome the present investigation as most timely and valuable.

The Life of Gas Meters Committee, to which I have referred, presented a summary of its 9 reports at the June meeting of 1923. Its existence had been unduly extended by the intervention of the Great War; but with the changes of personnel and a new President each year, there was a tendency to start over again matters that had already been dealt with. I rather flattered myself over having rendered one signal service in bringing that Committee to an end, and would give a word of warning lest the same tendency should occur again with a new Committee.

I wish we could have had this Interim Report confined to the computation of gas quantities, upon which subject it is authoritative. As a wider excursion into unaccounted-for gas it is somewhat scrappy, and there is a curious blend of the extremely elementary and the high-brow. With regard to the calculations, I hesitate to give another word of warning—that we may get too complicated. Accuracy is all very well, but it may run to seed. Too much accuracy is out of place in the computation of that which in itself constitutes an inaccuracy. Unaccounted-for gas, moreover, has a psychological as well as a mathematical make-up: in other words, there is the human factor.

However, we may blame Mr. Therm for the added complexity; this appears to be the reason, for instance, why benzole recovery either before or after the station meter must sometimes be brought into the picture.

I was rather puzzled by the passage under "Gas Sold," "The volume of gas passing through consumers' meters may be calculated from the total of the consumers' meter readings or from the amount of money obtained for gas sold at each of the prices charged for gas": but understand that there are undertakings that do not total their meter readings, and thus have to work it backwards.

In the same paragraph a reference is made to "bad debts," but that would surely be unaccounted-for money, not unaccounted-for gas.

"Station Meters", p. 10, reads: "The accuracy of the drum type of station meter is influenced by the method of proving". Surely that would apply to any type of meter. This is a most important consideration. Meters in the past have usually been calibrated when passing gas at an extremely slow rate, and that has been accepted as a criterion of the behaviour of the meter when working at its full capacity. There is at least one large undertaking not satisfied, but using a portable inferential meter to check accuracy at large flows. Mr. Robert Robertson, our President, has, I know, taken a keen interest in this part of the subject.

Estimating the temperature of the gas as measured in wet meters is always a problem, and the instructions quoted on p. 10 are as good as can be obtained, but the location of the thermometer is not the whole story.

Station Meters.

The second paragraph under "Station Meters" requires revision, for the condition described is only possible when the meter is at rest, and then only when the compartments are all unsealed or where there is a hole in the drum. It is evidently intended to state that the water-line gauge should have pressure agreement with the measuring chambers of the drum.

The third paragraph states "It is highly desirable that station meters should be proved not less frequently than once a year." In principle this would appear most important, but that depends on the technique of the re-testing. The late Mr. T. S. Lacey, Engineer at Beckton, used to say that so long as the drums and bearings of his meters were intact and the water-line maintained, he knew that they must be accurate and did not require them re-tested. That is certainly a sound policy as compared, for instance, with making a re-test at slow rate of a meter with perforations in the measuring compartments.

On p. 11 the reference to spot testing of consumers' meters, presumably *in situ*, is good, as meters may change in registration when they are removed and exposed to the atmosphere. The suggested use of a pilot burner of pre-determined gas rate is also good, but this would not give accuracy without pressure control.

At the conclusion, there is the long description of a cubic foot bottle. This is certainly valuable to a Paper on the Measurement of Gas. Is it a quibble to suggest that it is really irrelevant to the subject of the unaccounted-for? As the accepted standard of measurement, it is common to both sides, make of gas and sale of gas, and, therefore, cancels out in the unaccounted-for, so perhaps I may conclude as I began by finding fault with the title of the Report. So far as the measurement of gas is concerned, it is impossible to attach too much importance to a consideration of this fundamental problem. Accuracy in measurement is the vital necessity of all scientific data. When we have made all our corrections, it is possible to live in a fool's paradise over our measuring instruments. Gas is a most elusive product to catch, cure, and calibrate.

Determining Preventible Losses.

Mr. E. M. EDWARDS (Port Talbot): The method suggested in this Interim Report will guide undertakings in determining preventible losses. Although experience may show that some slight modifications are necessary, the method is sufficiently accurate for all practical purposes; and what we are chiefly concerned about is the value of the preventible losses and the means of preventing them. When we know the extent of the annual losses a decision can be made as to the costs which may justifiably be incurred in reducing them to an economic minimum.

In my own Undertaking at Port Talbot we have carried out systematic work since 1931 on gas unaccounted-for, and we have been able to reduce the figure from 10·6 to 5 per cent. But we have been gaining experience all along and I would like to mention the following important points in our policy.

In the first place, mains and services are tested every ten years. Secondly, meters are tested *in situ* every five years; and particular care is given to registration at low rates of consumption. Thirdly, in public lighting we apply the usual careful methods of checking, but in addition we pay particular attention to variations in mantle sizes, because we find appreciable differences with certain consignments of mantles. Burners are regularly tested. The number of leaking main joints and services located averages 7·5 leakages per mile of main.

We attach great importance to accuracy of meter registration because, for an equivalent volume, losses from defective meters are far more serious financially than losses from mains and services. In average practice the financial ratio would be approximately 3: 1. This ratio, of course, would vary in accordance with the detailed costs of each individual undertaking.

During our first survey of meter testing, 7,500 meters were tested and 7 per cent. were found to be registering slow in greater or less degree—*i.e.*, they were registering against the Undertaking. That survey was completed and we are now on our normal routine testing, and we still find that 4·9 per cent. of meters are registering against the Undertaking. Meters are tested at 2 cu.ft. or 4 cu.ft. per hour, or 10 cu.ft. per hour, with a carefully checked portable test meter. On an average, 14 meters are tested per man per day.

We have paid particular attention to apparatus with low-cut-down rates of consumption, and some of our results are rather interesting. If apparatus with low-cut-down rates of consumption are in use, the meters are tested at 0·25 cu.ft. per hour. During recent years I have paid close attention to meter testing and registration at low rates of flow, and our present practice in the meter shop is that all new and repaired meters must register accurately at 0·25 cu.ft. of gas per hour. It is not unusual to find that new meters, from manufacturers of experience and repute, will not pass this test at 0·25 cu.ft. of gas per hour. Most of the meters removed from the district will not pass the test and many do not register at all at this rate of flow. The meters are tested against a small accurate wet meter which is itself tested regularly with the Gas Referee's 1/12th cu.ft. proving measure. An alarm bell is fitted to the test meter to attract the attention of the meter repairer when the test is almost completed, and this helps to cut down cost.

While meter valves are in general giving good service, I think we are inclined to expect too much from the present type of meter valve, which has been in use for many years,

since the dry meter supplanted the wet meter. If we consider the work they have to do we shall appreciate the need for a special investigation with a view to improving the design of meter slide valves and seatings, or determining whether there is an alternative type of valve. In the course of the working life of, say, a Number 2 standard meter, registering some 200,000 cu.ft. of gas over a period of ten years, we shall find that the slide valve travels something like 16·6 miles. We expect the two metal surfaces to rub on each other over that distance and at the same time to put up with any deposits which may be formed in the meter, and yet at the end of that ten-year period we expect the valve to be absolutely gas tight. I think there is room for improvement in the design of meter valves, because that is where we have most of our trouble.

An important point in our experience is that when new or repaired meters are put into service they should be within ±0·5 per cent. from net. The prescribed tolerances of 2 per cent. fast or 3 per cent. slow, while representing a necessary margin, offer rather a wide limit, and the aim should be to work as nearly as possible to the net figure. We should not permit meters to go out to the district when reading 2 per cent. slow. Such a meter is efficiently correct, but it is giving away 2 per cent. of our revenue to start with—and a meter will work against us soon enough when once it has been fixed on the district.

This matter of meter testing is important, and its importance is not confined to any particular undertaking. I have an interesting analysis of *in situ* testing of 4,250 meters in another Company for which I was responsible. That analysis showed that two meters were leaking; 98 meters were not registering at all at 5 cu.ft. per hour; 2 meters were more than 3 per cent. fast; 35 meters were more than 3 per cent. slow; and 84 meters were more than 10 per cent. slow. The total number of defective meters was 221, equivalent to 5·2 per cent. of the total number. While it is difficult to estimate the actual quantity of gas lost due to defective meters, in this case again the gas unaccounted-for was reduced from 12·9 to 6·1 per cent. in four years. Of course, other factors were involved, but meters constituted a very serious factor in the savings effected.

Holder Stocks.

Mr. P. C. GARDINER (Tottenham): The principles underlying the scheme set out by the Research Committee are, of course, perfectly sound and I am sure the method will be generally approved. In my opinion, however, it requires the addition of one further factor to make it completely acceptable. No mention is made of holder stocks, the variation in which may constitute an appreciable proportion of the unaccounted-for computed in accordance with the method proposed.

Following the example given in Appendix 4 in which a December quarterly make of 1,606 million cu.ft. is referred to, I have made a calculation based upon figures of the Undertaking which it is my privilege to serve, the output being approximately the same as that noted in the Appendix. Our total holder capacity is 18 million cu.ft. which incidentally represents 87 per cent. of the maximum day's make. Now, of this 18 millions the variation between the beginning and end of a quarter could be as much as 10 million cu.ft., and such variations would mean $\frac{10}{1,606} = \pm 0{\cdot}6$ per cent.

This means that a variation of over 1·0 per cent. in the unaccounted-for between two comparable quarters could be entirely masked by the recommended procedure. I hope, therefore, the Research Committee will consider the inclusion of change in holder stock as an item in the gas accounted-for.

With this adjustment, I consider the gauging of the gas at the Works is quite satisfactory; but there are three points on the distribution and accounting side of the business, which appear to be of great significance, and these are very difficult to compute satisfactorily. The items referred to are: 1. Temperature of gas passing through consumers' meters. 2. Inaccuracy of consumers' meters. 3. Variation of accounting periods.

The Committee has dealt with the question of the temperature of consumers' meters and has put forward a basis for correction. The conditions under which these meters work have, however, changed so materially during the forty years since the correction table was formulated that I fully support the suggestion in the Report that an investigation into the present-day conditions should be made before the figures of Table 2 are acceptable.

The inaccuracy of consumers' meters is a very important matter. It is obvious that the Committee had this in mind as they have drawn attention to the method of gauging test meters which can be utilized for the checking of secondary standards used for proving consumers' meters. I hope it will be found possible to induce manufacturers to make meters which can not only be relied upon to comply with the statutory degree of accuracy demanded by the Sale of Gas Act but also to reduce the error in registration to vanishing point.

In view of the provisions of the Sale of Gas Act it seems to me that new meters can be accepted as being, on the average, about half of 1 per cent. slow. Even with new meters throughout the district, therefore, the unaccounted-for is likely to be ½ per cent. and this may increase with the average age of the meters. I should, therefore, like to see all meters slightly on the fast side when new in order to minimize the loss from this cause.

My third point concerning the accounting period is a most difficult one. The Interim Report does not make any recommendation as to how this should be approached. I therefore ask the Committee to consider the following proposal: Each consumer's meter to be read as nearly as possible on the same day of each year (or other period) and the differences between the last readings of each year be accepted as the quantity of gas consumed in the latter year. The overlapping and odd consumers should cancel out, and it is submitted that this figure will be preferable for comparison with the gas made in the calendar year to that ascertained by any other procedure.

I should like to stress the recommendation that attention should be paid to the proper estimation of unregistered gas used, which often represents an appreciable proportion of the gas sold.

I cannot terminate my remarks without reference to the very illuminating tables showing the influence of the gas drying process upon gas quantities given in Section 5. The last two tables showing the effect upon therms indicate a rather surprising result which deserves careful study. These tables, surely, constitute another factor in the argument in favour of gas drying.

Temperature at the Meter.

Mr. E. V. EVANS (Chairman, Research Executive Committee): It may be of general interest for me to report that we have induced some 500 of our employees in South London to read the temperature of gas at the meter twice a day for a period of six months. That will give us some information regarding the actual temperature at which the gas exists on the district throughout that period.

The other point I want to make is that I hope we can induce Dr. Hollings and his Committee to work under far wider terms of reference than those which have been adopted. I hope that not only will they standardize the methods of determining the unaccounted-for gas, but that they will start to investigate the main causes. A number of undertakings, I am sure, will help them with information, and if they will adopt wider terms of reference I think we shall be on the road to clarifying a very important problem in our Industry.

Mr. J. H. BINGHAM (Metropolitan Meter Company): It is hardly necessary for me to say that I stand here in defence of the oft- and much-maligned meter. I admit that in all the equipment of a gas undertaking there is probably nothing more important nor anything that has been the source of more contention than the meter for measuring the gas supply to the consumer. It matters little if the cost of production is reduced by the adoption of modern methods and machinery if the undertaking supplying the gas is not paid for the gas which is consumed. I admit also that the gas meter is, after all, the sole accountant for the individual consumer, and that the service it renders is of the utmost importance. I should like to tell you something of the incidence of its behaviour—not misbehaviour—on the question of unaccounted-for gas,

and to advance a few comments for consideration when further investigation is being made.

In the section of the Report headed "Consumers' Meters" it is stated that "A defect having a major influence on gas unaccounted-for is the passing of unregistered gas at low rates, and it is particularly important where a gas installation includes one or more appliances with continuously-burning pilots." The latter part of this statement, which I will deal with first, is misleading, as it would appear that with an increasing number of pilots there is an increasing amount of unregistered gas. This must not be assumed, for while a poorly conditioned meter may not measure one pilot consumption, if there are two or more pilots the meter might function and register the consumption with a reasonable degree of accuracy. I consider that it would be fairer to substitute for the phrase "one or more" the words "two or less," and it is only with reluctance and under certain conditions that I agree to concede a number as high as two.

Now for the earlier part of the statement, in which the passing of gas unregistered at low rates is said to have "a major influence on gas unaccounted-for". I am tempted to challenge this statement. What I do consider to be a major influence on the determination of the gas consumed is the overloading of meters beyond the capacities for which they are designed. There is no mention whatsoever of that in the Report. If a meter will not register a pilot consumption, its inability to do so can be observed; but the failures to register correctly at overloads cannot be seen in service, and the losses due to this ill-treatment may be much the greater.

If that which is referred to in the Report as a "major influence" is proved—my own research into the question is not convincing on the point, and, indeed, so far it has been the reverse—then the weaknesses may be due either to inaccurate construction, which would be the makers' responsibility, or, what is more than likely, to the nature of the gas which is passed through the meter, and that is entirely within the control of the undertaking.

Correction for Temperature.

I would like to refer now to the correction for the temperature of the gas passing through consumers' meters. When the suggested calculations have been made, has anything been achieved? Are we any nearer the truth, or have we been merely juggling with figures? I say "juggling"—and I hope the use of the word will be pardoned—because the base volume, that is, the aggregate of the recorded consumptions, may be above or below the actual volume passed through the meters. Having regard to the tendency for meters to work fast in service, which does not appear to be recognized by some of the previous speakers, then the base volume itself may already be overweighted; in other words, the gas charged for may be in excess of the amount passed through the meters. I know that this may sound preposterous to some of you, but it is by no means impossible for such a condition to arise, and I believe it is one which has actually been experienced.

If support is needed for my statement that the tendency is for meters to work fast in service, I will quote the American practice. In our own country the statutory regulations allow of a meter being anywhere within a range of from 3 per cent. slow to 2 per cent. fast. In America, those States or Corporations which require their meters to be verified, and not all of them do, will not allow any margin on the fast side. I think that that is a recognition of the tendency to which I have alluded.

Again, it is observed that correction is made to the mean daily temperature, which is taken as the arithmetic average of the maximum and minimum shade temperatures of the day. This mean temperature, however, may vary by several degrees from the mean temperature during the period around the peak load, and as a variation of 5° F. will affect the volume to the extent of 1 per cent., I think this is a point warranting consideration if allowance for it has not been made already.

I would couple with this also the observation that the 5 per cent. registration range allowed by the statutory regulations is one which requires a temperature range of 25° F. to accommodate it.

In view of what I have said, and having regard to the assumption that the typical calculation shown in Appendix 4 is really a typical one, I again ask, is it worth while attempting any correction? In the calculation given, the weighting of the recorded volume is equivalent to no more than 4 per cent.

Dr. Hollings Replies.

Dr. HOLLINGS, replying to the discussion, said: I hope the Committee will have an opportunity of considering some of the very valuable points which have been raised and of making a much more complete answer in writing than I can make this afternoon.

I should like to say how much I have appreciated the support of Mr. Ruthven and Mr. Lacey, not only in respect of their contributions to the discussion, but also, of course, in the deliberations of the Committee. I am sure the members of the Committee will be very interested to hear of the experiments which Mr. Evans has put in hand.

The various criticisms made by Mr. Parkinson and Mr. Bingham will, I feel, prove to be very healthy *stimuli* to the work of the Committee. If Mr. Parkinson is afraid that we shall drag on our proceedings unduly, and if he thinks that an executioner will be needed, I can only remind him that we now operate under the control of a very effective Executive Committee, of which Mr. Evans is Chairman!

Questions have been raised by Mr. Gardiner relating to holder stocks, and obviously that is a matter which will have to be taken into consideration. My own view is that the error which is likely to be introduced due to failure to correct for the holder stocks is less than the error likely to be introduced due to any change at the end of an accounting period. But it should not be forgotten that both those errors are of the type which must inevitably cancel themselves in time; they do not affect any long-period comparison between one undertaking and another.

Then Mr. Gardiner appeared to be under a misapprehension on one point, which I should like to clear up at once. He said he agreed with the recommendation that there should be a further examination of this table of temperature corrections before this standard method is adopted. That is not what the Committee had in mind. On the contrary, we are very anxious that the table included in this standard method of correcting the gas volumes should be adopted at once, without waiting for any correction which may have to be made, because it is our view that any correction which may have to be made ultimately, will have a very small effect on the final answer—certainly only some very small fraction of the 4 per cent. to which Mr. Bingham has referred.

15th Report of the Gas Education Committee, 1937-38

[ABSTRACT]

Communication No. 195

Included in the Report are the names of successful candidates in the 1937 Examinations of the Institution; the Questions set in the Examinations; and also the Report of the Examiners. These were published in the "JOURNAL" for July 20.

In May, 1938, Sir Francis W. Goodenough resigned the Chairmanship of the Gas Education Committee, a position he had held since its inception in 1923. The thanks of the Committee are due to Sir Francis Goodenough for the great services rendered by him as its Chairman. Mr. John Terrace (London) was elected Chairman and Mr. Francis C. Briggs (Dudley) was elected Vice-Chairman of the Gas Education Committee by the Council on 31st May, 1938.

Administration

The year 1937-38 has been the first in which the revised conditions described in detail in the 14th Report of the Committee have been operative. In particular, mention must be made of the changes in the titles of the Major Course Examinations and Certificates for Gas Engineering and Gas Supply to Gas Engineering (Manufacture) and Gas Engineering (Supply), and the raising of the standard of the Ancillary Subjects for the Higher Grade Certificate in Gas Engineering (Supply) to bring it into line with that of Higher Grade Gas Engineering (Manufacture). At the same time a new Certificate in Gas Supply was introduced of the same academic standard as the old Higher Grade Certificate in Gas Supply, but with the important difference that it is not part qualification for any form of membership of the Institution.

These changes had unfortunately to be made shortly before the opening of the yearly Sessions and the Committee wishes to record its appreciation of the helpful co-operation of the Principals of the many Technical Colleges throughout the country, at which Approved Major Courses in Gas Engineering are conducted, in putting these revised Courses into operation.

The usefulness of the improved standard of the Examination in Higher Grade Gas Engineering (Supply) has been generally recognized. Moreover, the higher status of the Certificate in Higher Grade Gas Engineering (Supply), forming as it does a part qualification for election to corporate membership of the Institution under By-law 14, has appealed to Candidates and many have applied to convert their old Higher Grade Certificates in Gas Supply into Higher Grade Certificates in Gas Engineering (Supply) by taking the necessary additional Ancillary Subjects.

An important change has been made in the Regulations as regards the eligibility of Candidates to sit for the Higher Grade Examinations of the Institution. Up to this year, in accordance with the Regulations, Candidates before being eligible to sit for the Examinations had to be engaged on the practical side of the Industry. These Regulations were found to be difficult to administer in practice. The Council, on the recommendation of the Gas Education Committee, therefore decided to modify these Regulations so that from and including the 1939 Examinations, Candidates for the Higher Grade Examinations in Gas Engineering (Manufacture) or (Supply) will not be required to be engaged on the practical side of the Gas Industry. It is pointed out, however, that these alterations do not affect in any way the requirements for membership as stated in the By-laws.

The Committee has revised the Syllabi and typical Courses for the Major Course Examinations, and the Council of the Institution, on the recommendation of the Committee, has approved the following revised typical Courses for the Ordinary and Higher Grade Examinations in Gas Engineering (Manufacture):

Ordinary Grade

1st year.—Practical Mathematics S1
Physics S1 *or* Engineering Science S1
Inorganic Chemistry S1

2nd year.—Practical Mathematics S2
Inorganic Chemistry S2
Engineering Drawing S1

3rd year.—Inorganic Chemistry S3
Engineering Drawing S2
Gas Engineering (Manufacture)

Higher Grade

4th year.—Engineering Science S2
Practical Mathematics S3
Electrical Engineering S2

5th year.—Heat Engines S3
Applied Mechanics S3
Gas Engineering (Manufacture)

The main differences to be noted are that Physics S1 or Engineering Science S1 is to be taken in the first year and Mathematics S2 in the second year of the Ordinary Grade Course, while in the Higher Grade Course, Electrical Engineering S2 now takes the place of Building Construction S1 and Practical Mathematics S3 replaces Practical Mathematics S2, which is now taken in the second year of the Ordinary Grade Course. Certificates for External Candidates in accordance with these revised Courses will be awarded on the results of the 1941 Examinations.

These revisions will only affect Internal Students as and when revised Courses are submitted by the Technical Colleges for approval.

The Committee desires to draw attention to the large number of candidates for the Examination for the Diploma in Gas Engineering (Manufacture). The Committee was gratified to find that this large number was not due to the acceptance of a Second Class pass in the Higher Grade Examinations, since of the 26 Candidates who presented themselves for Examination this year 23 or 88 per cent. had obtained a First Class Certificate.

In this connexion the Committee is pleased to be able to announce that it has recommended the names of two candidates for the award of the Charles Hunt Memorial Medals.

Examination Results

The Comparative Statistical Schedule of the 1937 and 1938 Examination Results indicates that the number of examinees is increasing.

There were 26 Candidates for the Diploma in Gas Engineering (Manufacture) and 3 Candidates for the Diploma in Gas Engineering (Supply).

The Charles Hunt Memorial Medals for 1938 have been awarded for Gas Engineering (Manufacture) to J. Malsbury (Hertford) and for Gas Engineering (Supply) to J. B. Walsh (Stockport).

Approved Courses

(*a*) *Major Courses*

Courses have been approved for 4 new Centres. Of the 132 Courses approved, 71 Courses have been approved for Gas Engineering (Manufacture), 47 for Gas Engineering (Supply), and 14 for the Certificate in Gas Supply.

(*b*) *Minor Courses*

2 Centres have been added to those having Approved Minor Courses and 8 to those having Approved Courses in Gas Fitting. Of the 136 Courses approved 6 were approved for Gas Works Practice, 29 for Gas Supply Practice, and 101 for Gas Fitting.

Ancillary Subject Examinations

Arrangements were made by the Institution for 66 External Students, 5 of whom were overseas candidates, to be examined by the various Examining Bodies under the Education Regulations in the Subjects ancillary to Gas Engineering (Manufacture), Gas Engineering (Supply) and Gas Supply.

Examinations, 1939

The next Examinations in Gas Engineering (Manufacture) will be held on 29th April, 1939, and in Gas Engineering (Supply) and Gas Supply on 6th May, 1939. Applications to sit for these Examinations must be received by the Secretary of the Institution not later than 28th February, 1939.

THE INSTITUTION OF GAS ENGINEERS

EXAMINATION RESULTS, 1938

The Results do not include Candidates (a) *who withdrew before the Examination, or* (b) *who, having Second Class Certificates, re-sat and failed to secure First Class Certificates, or* (c) *whose Examination has not been completed.*

(i) COMPARATIVE STATISTICAL SCHEDULE OF THE 1937 AND 1938 EXAMINATION RESULTS

Examinations.	1937					1938				
	First Class with Distinction.	First Class.	Second Class.	Failed.	Total.	First Class with Distinction.	First Class.	Second Class.	Failed.	Total.
External—										
Diploma in Gas Engineering (Manufacture) ..	—	4	1	1	6	—	6	10	9	25
H.G. Gas Engineering (Manufacture)	—	8	15	5	28	—	6	17	5	28
O.G. Gas Engineering (Manufacture)	1	5	10	14	30	—	3	19	14	36
O.G. Gas Engineering (Manufac.) (single subject)	—	—	—	—	—	—	1	2	—	3
Diploma in Gas Engineering (Supply)	—	1	2	—	3	—	1	—	2	3
H.G. Gas Engineering (Supply)	—	—	—	—	—	—	9	6	1	16
H.G. Gas Supply	—	6	7	1	14	—	—	—	—	—
Certificate in Gas Supply	—	—	—	—	—	—	2	3	1	6
O.G. Gas Engineering (Supply)	—	7	23	8	38	3	8	10	5	26
O.G. Gas Engineering (Supply) (single subject)	—	9	5	—	14	—	9	3	1	13
Total	1	40	63	29	133	3	45	70	38	156
Total, per cent...	0·7	30	47·3	21·8	—	1·9	28·8	44·8	24·4	—
Internal—										
H.G. Gas Engineering (Manufacture)	1	11	24	11	47	—	13	31	11	55
O.G. Gas Engineering (Manufacture)	1	6	43	11	61	6	20	22	14	62
O.G. Gas Engineering (Manufac.) (single subject)	—	5	6	1	12	—	4	3	1	8
H.G. Gas Engineering (Supply)	—	—	—	—	—	4	8	8	12	32
H.G. Gas Supply	4	19	38	14	75	—	1	2	—	3
Certificate in Gas Supply	—	—	—	—	—	—	4	37	8	49
O.G. Gas Engineering (Supply)	4	14	45	33	96	8	25	67	43	143
O.G. Gas Engineering (Supply) (single subject) ..	2	6	6	—	14	5	6	3	—	14
Total	11	62	162	70	305	23	81	173	89	366
Total, per cent...	3·6	20·3	53·2	22·9	—	6	22·2	47·4	24·4	—
Grand Total	13	101	225	99	438	26	126	243	127	522
Grand Total, per cent.	2·7	23·3	51·3	22·6	—	4·8	24·2	46·6	24·4	—

Mr. JOHN TERRACE presented the Report.

Discussion.

Mr. F. C. BRIGGS (Dudley, Vice-Chairman, Gas Education Committee): I propose the adoption of the report. With the further extension of the matter included, it is hoped the report will be found more than ever the guide, philosopher, and friend of teacher and student.

The general report of the Committee upon the first few pages is quite short, and I would commend its perusal to all interested in the scheme. The only paragraph I would desire to emphasize is the last one. The thanks of the whole Industry are certainly due to all those who help so willingly to administer the scheme in the course of their ordinary duties; but they are especially due to the voluntary workers for the scheme whose only reward is a sense of a valuable service consistently and unostentatiously rendered. These are the members of Committees, and particularly the examiners and assessors. We tender to them our grateful thanks.

The Gas Education Committee has been said, not without reason, to be one of the Institution's most important Committees; but its report now becomes the Cinderella of the family, the last item of the last day of the last meeting of the Institution of this year—but definitely not a Cinderella in rags. It is to be hoped that this will not detract from either the opportunity or inclination for full discussion.

In this connexion I would respectfully suggest to those in authority that this is not the proper time for the presentation of the Education Report. The Education Committee is not a Sub-Committee of the Research Committee, and after two days' hard study of research, all those who have stayed to hear the Education Report presented ought to be thanked for their forbearance.

In my presence a few days ago a knowledgeable person not in the Industry said that the rapidity of development of technique in the Gas Industry was greater than that of the majority of industries and as great probably as any he knew. With this opinion I think we should all agree.

It is the Committee's task to keep abreast of this rapid development. It is a comparatively small Committee, and it earnestly desires your constructive criticism. It desires the opinions of the Principals and Teachers of Technical Institutes to whom it is indebted for the practical administration of its schemes, and this is the only opportunity which occurs for these to be expressed publicly.

It also desires the opinions of members of the Institution. They have more opportunity of expressing them through the District Gas Education Committees and in the District Associations upon the reports of the District Gas Education Committees. These views come to the Committee, but opinions expressed here now are probably the most valuable, making obvious the extent of support of the views expressed. It is hoped therefore that the adoption of the Committee's Report will not be considered a purely formal matter.

The work of the Committee is educational in a double sense. It has to have regard to the continued mental training of the secondary school non-university graduate type of students which are in the majority, and at the same time to do this by arranging for the teaching of subjects which have a potential practical value and application to the students' work in the Industry. Considerable attention has been drawn during the year in Papers and Addresses to the question of education and the work of the Committee. The necessity for, and the value of, education is probably one of the few matters in our Industry upon which there is unanimity of opinion. This, however, has to be translated by the Committee into a curriculum and a syllabus. It is probable that nearly every member has on his Staff at least one person who has passed through the Institution's course of education. Is the product satisfactory? Is the knowledge gained such as the Industry needs?

With the growth of the Industry the Committee's standards inevitably rise from time to time. How much farther and in what direction is it desirable to go? How much time can you allow your juniors for theoretical training? I believe they have already gone to the limit in their own time.

There is so much knowledge in the world of both interest and value that a man could spend most of his life acquiring it—and then achieve no useful purpose in the service of his

fellows. Where is the line to be drawn and what guidance is to be given to the young student? If the Committee is to continue to function successfully it needs not only your continued support, but your practical help.

Mr. H. C. CREASEY: Year after year we record the changes we have made in our regulations or our scheme, or we foreshadow changes that are to come. Those changes are due almost entirely to two causes. One is that the standard of candidates presenting themselves for certificates is rising, and the second is the enormous industrial development, more especially in connexion with gas supply. Unfortunately, that development is not uniform all over the country, either in extent or character, and already we have been landed on the horns of a dilemma. We have to provide for two sets of students of different standards, different training, and different aims, for one examination in the main subject. It is unfortunate, and I do not think anyone will regard it as being anything more than a temporary state of affairs, but for the time being it is bound to give us a certain amount of anxiety.

Two considerations have impressed me very much during the last twenty years. One is the extent to which the Gas Industry is dependent upon men who have to obtain their training in part-time evening classes. The other is the enormous advance in those branches of pure science, in the ancillary subjects, which bear upon the Gas Industry, and in the technology of the Gas Industry itself. It is becoming increasingly difficult for a man to acquire a knowledge of the ancillary subjects and of the technology within the limitations of part-time evening instruction, and it will become more and more serious and not less serious as the years go on. It is on those grounds that I would plead, not for the first time, for an exploration of the possibilities of wider facilities to attend long or short classes for day or whole-time instruction. I think that problem will have to be faced sooner or later.

In spite of these somewhat pessimistic remarks, I am bound to declare myself still an optimist after 15 years' association with the Scheme.

Freedom from Shackles.

Dr. P. C. L. THORNE (H.M. Inspector): I feel that this year the Committee is a good deal happier by reason of its freedom from certain shackles which were not of an educational nature; for instance, there is the freedom from enquiries as to the employment on the practical side of the Industry, and so on, which were always rather artificial and have not served the useful purpose for which presumably they were intended. I am concerned more particularly with the practical problems of the working of education for the Gas Industry, and as I see them there are several aspects which have to be dealt with rather separately in order to conduct instruction, as we are convinced it is best conducted, in classes wherever possible. We must have buildings, teachers, and students. The question of buildings and equipment is one for the Board of Education and the local authorities, although one can record with gratitude and appreciation the efforts which some undertakings have made to provide specialized equipment, and also the practice in a great many undertakings of supplying both the equipment and buildings, particularly for gas fitting instruction. I think without that it would be almost impossible to conduct our instruction in gas fitting, unless we could borrow appliances for demonstration and so on. Such help is very much appreciated by the people on the educational side. The buildings in many places are being very much improved, although perhaps some of the subjects are the Cinderellas of the technical subjects and tentatively we have to work in rather unsatisfactory buildings.

So far as the students are concerned, I should like to emphasize the importance of part-time day instruction. There are many difficulties, geographical and otherwise, which face the students in attending classes after working hours, and the solution of that problem is to allow them to attend classes during working hours, either by releasing them early from work or, better still, releasing them for half a day or a whole day, so that they can give their minds to the subjects they are attempting to study.

Then there are the teachers. Here again we have an admirable body of men teaching the main subjects, practically all of whom are employed in the Industry, and we have a fine body of men outside the Industry who deal with the ancillary subjects. I plead for your consideration and support for the teachers' courses which are run in London and Birmingham. For the last two years these courses have been mainly for teachers of gas fitting. I am hoping to introduce in Birmingham next year a more advanced section dealing with gas supply, and I trust that managers of undertakings will make every effort to allow both those who are actually teaching and those who are likely to begin to teach (it is a good thing to put them right before they go wrong) to attend the course, either the one that is held in London for the Metropolitan area or the one that is held in Birmingham for the Provinces.

I do not think the Gas Education Committee is likely to fall into complacency; but the examinations and the scheme must be all right because so many people take them. We notice this year with interest that the numbers are up again; that does not surprise me, and I should not be surprised if the numbers are up a little more next year. Propaganda with regard to the Education Scheme has been going on during the last two years, and we are getting the advantage of it, not merely in the students, but also the graduates who have passed examinations and will be qualified persons for the work of the Industry in the future.

Report Should be Considered Earlier.

Mr. H. D. MADDEN (Cardiff): In the first place I should like to express the views which were put forward by Mr. Briggs about the fact that this Report is the last for consideration in the programme of this Research meeting. I do hope that the Council of the Institution will include it at an earlier stage, so that so many more people can attend and discuss it, because I feel that the whole basis of the Institution, its personnel and its research, is dependent on the success of the Education Committee's scheme.

I have been on the Committee since its inception fifteen years ago; I became the first Chairman of the Board of Examiners at that time and also the assessor for Great Britain. You can hardly realize the tremendous advance which has been made by students in that time. I can assure you that when I tried to co-ordinate the papers, the passes, from different parts of the country at the beginning, I was appalled by the work which some institutions would pass and others would not pass. However, after years of work, we have put that right, and to-day we have a standard demanded in this Examination Committee and a standard of education—I stress the education—very much higher than that of fifteen years ago. That is all to the good, and I believe that all of us who are in positions of administration find that the juniors to-day are better educated, better trained, and more keen to tackle their problems than they have ever been before. I attribute that to the attention they have paid to the syllabus of the Institution, and I hope that that process of advancement will go on from year to year.

I should like to refer particularly to the functioning of the district Committees, for I am afraid we are not so strong as we might be. I have heard complaints from colleagues that their District Education Committees have not met for a year or two years. I should like to see a stronger link between us in the Provinces who are trying to operate these schemes and our Committee in London. Much can be done; there are far too many students to-day who are taking correspondence courses, and I should like to see that position remedied if possible. If the district schemes worked strong and well, we might, in collaboration with the technical colleges and others, be able to advise our headquarters Committee of the best means of getting over such difficulties. I do not say that in all cases the correspondence classes will be eliminated; they cannot be. Indeed, I say they are extremely good. But that is not the point. It is the co-ordination of education with the Central Committee that we in the provinces are aiming at. I have lived my life in the Gas Industry and I have had a fairly long innings, and I can well remember how cold water was thrown upon technical education some forty years ago; anyone who studied the problem of technical education in those days was rather pooh-poohed. But that outlook has gone, and it has gone for ever. It is realized to-day that, if we are to take advantage of research, we must have the best educated brains to deal with that research, and to turn the results to commercial

advantage. I feel that when gentlemen such as Sir David Milne-Watson, of the Gas Light and Coke Company, do so much to provide staffs for our higher education and give us all a lead, we in our turn should encourage our juniors to secure the highest certificates they can. To me, as an old Chairman of Examiners, if there is one point more than another which indicates the success of the scheme, it is the fact that so very large a number of men have taken the diploma examination this year. That ought to please the Chairman and Secretary of the Education Committee and convince them that they are indeed doing good work.

Mr. G. E. CURRIER (Bradford): Revision of the Education Regulations has taken place from time to time since the inception of the Gas Education Scheme in 1923, and the latest amendments are welcomed. Formerly candidates in the Higher Grade Examinations in Gas Engineering (Manufacture) or Gas Engineering (Supply) were required to be engaged on the practical side of the Gas Industry. Although this qualification is still necessary for membership of the Institution, it is no longer necessary for these Higher Grade Examinations, and this is regarded as a step forward which will be particularly encouraging to those engaged on the supply side of the Industry, but who were formerly regarded as not being engaged on the practical side of the Industry.

Summaries of Theses.

Many have felt for some time that the successful Theses for the Diploma Examinations should be published in the Technical Press, as some of these Theses may deal with work of importance to the whole Industry. The publication of summaries of the successful Theses in the Report of the Gas Education Committee is, therefore, considered a most useful addition to the Report.

Time does not permit of my mentioning other revisions that have taken place, except to say that all the amendments and alterations would appear to be for the better and smoother working of the Education Scheme, and to improve the standard of education required, both of which are all to the good of the Industry.

With reference to the District Education Committees, I would say that although I do not regard their duties and work as being arduous, I do think that the District Committees form a most valuable link between external students and the Institution, and also do useful work in collaboration with the Technical Colleges in the administration of the Education Scheme.

I would like to say that the Yorkshire District Education Committee greatly appreciate the valuable help which Dr. Mason has given during the last seven or eight years as a member of our Committee, and while we regret the loss of his services due to his transference to another district, we shall be pleased to have the assistance and guidance of his successor on the Committee, Mr. Painter.

We have found that the Board of Education Representative is of the greatest help in dealing with intricate points which arise from time to time, and, further, has great persuasive powers with the Principals of Technical Colleges.

Mr. A. E. RUFFHEAD (Darlington): As Chairman of the North of England District Committee I have been asked to make a few remarks. First I should like to congratulate the Gas Education Committee upon its report and particularly upon the decision to print some of the successful theses submitted for the diploma examination.

I am pleased to be able to report that in our district more students are taking courses during the coming season than was the case last year. We all feel in the North that the alterations to the regulations and the syllabus are all to the good and will benefit the men who are taking the examinations. At the same time, it was felt at our recent district meeting that the standard of the questions set for the Higher Grade Certificate in Gas Engineering (Supply) was rather on the low side, some of the questions being more in the nature of Higher Grade Gasfitting problems, with which perhaps men such as those referred to by Mr. Currier would not come into contact, although they are eligible to take the examination. That may account for the disappointing answers given in the examination, which are mentioned in the Report. It is felt that in the Ordinary Grade Examinations it would be an advantage for one standard paper to be set by an outside examiner, as suggested in the Report of the Board of Examiners.

Perhaps I may be allowed to make one or two personal remarks. I am pleased to know that the Institution Council is investigating the question of adequate salaries for the staffs of gas undertakings, for I feel that that is bound up to a certain extent with the success of our education scheme. If we want the best men and if we are going to train them, we must pay them adequate salaries.

As a member of the General Services Supply Committee of the Executive Committee of the British Commercial Gas Association, which has been endeavouring to formulate a scheme for the education of gas salesmen—*i.e.*, to provide some system of education apart from the correspondence course—I am very pleased that this matter has now been referred to the Institution. I do hope that the Council will see their way to adopt it and that the Education Committee will provide for the whole of the education and for the examinations required in the Industry. I am referring, of course, to examinations which I hope the Education Committee will provide in sales technology, and possibly in pure salesmanship.

I should like to mention one example in the hope that others will emulate it. It is the example set by one of our Past-Presidents of the North of England Association of Gas Managers. At the end of his year of office he very kindly put down the sum of £250, to which the North of England Association of Gas Managers added a further £250, to form a Fund called the "North of England Gas Managers' Association and Arthur Clement Hovey Education Trust Fund." The objects are to assist employees in the Gas Industry in the further study of educational subjects approved by the Advisory Committee, and to reward meritorious work by such persons on subjects approved by the Committee. The persons to whom such disbursements may be made, of course, are Members, Associates, or Students of the North of England Gas Managers' Association who shall have obtained a certificate or certificates in educational subjects, or shall have conducted or accomplished work approved by the Advisory Committee of the Fund; or they may be persons, being employed by a gas undertaking in the area of the North of England Gas Managers' Association, and ineligible for membership of the Association, who are studying for the major course certificate of The Institution of Gas Engineers or the degree of B.Sc. at a British University. I think the Fund is a very fine thing; I am sorry it is not bigger, but we hope that it will grow. We have quite a nucleus already by which we are able to assist the juniors, who at the commencement of their careers have not a large amount of ready cash available. We assist them in regard to travelling expenses or fees, or in some other way. I hope that other people will emulate the example of Mr. Hovey.

Technical Institute Principals.

Dr. J. N. LONG (Principal of the Westminster Technical Institute): I should like to thank you for the very kind remarks of appreciation which have been made concerning Technical Institute Principals. We have heard that the presence of a Board of Education Inspector was helpful in getting something out of Technical Institute Principals. That may be so in the north, but so far as London is concerned may I say on behalf of my colleagues how very much we appreciate your words of thanks? This is the only public meeting I attend, I think, at which part of the proceedings are devoted to thanking the people who are running the Education Scheme. All will be well now that Mr. Terrace is back again; we who are interested in education are very, very pleased to see him.

I want to congratulate you on repealing a stupid, unworkable regulation. Already the repealing of that regulation as to employment has encouraged an enormous number of students to study for your Higher Grade Gas Engineering (Supply) Certificate. I said two years ago that that would be so, and you are getting a large number of very good men coming along for the Higher Grade Supply Certificate. Whether or not they join the Institution does not matter; you have provided them with a very good qualification.

Since you have asked for criticisms and suggestions, I would like to put in a word for the gasfitter, about whom I am always keen, because, as I have said before, no matter how good your salesmen are, it is the gasfitter who is constantly in and out of the consumers' houses, and I am extraordinarily keen to give that man the squarest deal we can give him.

What I want you to do for me is that, if a fitter has a Higher City and Guilds Certificate in gasfitting, you will automatically exempt him from the first year of the Gas Engineering (Supply) Course. In order to get his certificate he has attended an evening institute for five years; if he is good enough and wants to go on the supply side, he must not be expected to start again in the first year among boys of 17 years of age. We want a man with that qualification in gasfitting to go into the second year of the supply course without any question. If you can do that for us at Westminster we shall be very grateful.

Mr. H. MOYS (Member of the Board of Examiners): There are two small points I should like to mention in connexion with the gas engineering side. You say that you think the time has arrived for a common examination in the Ordinary Grade Gas Engineering. As one who is connected with an institute in a teaching centre which teaches for both the Ordinary and the Higher Grade Certificates, I quite agree with you. I would suggest, however, that you do not stop there, but that you will have a common examination for the ancillary subjects as well. Inasmuch as the centre with which I am concerned deals with Ordinary Grade and Higher Grade people, we have some students who have already attended other teaching centres before coming to us, and it is quite apparent that there is a very different standard in regard to the ancillary subjects among the various institutions. By "different standards" I mean that a different standard is required in order to obtain 60 per cent. in the examination. I would remind you that in order to get the Ordinary or the Higher Grade Certificate you require 40 per cent. in the ancillaries for a pass, and 60 per cent. for a first-class. I am rather of the opinion that the 40 and 60 per cent. have quite different values at different centres, and I would suggest that in the future, if it is at all possible, a common examination should be set, not only for the main subject, but also for the ancillary subjects.

It has been mentioned by Mr. Briggs that the report of the Education Committee is the last report for consideration on the agenda of the Research Meeting. I would call your attention to the fact that the students have to take their examinations for the Ordinary and Higher Grade Certificates at the very end of the week—on Saturday afternoon and evening. In London the examinations are usually held when there are many people passing along the streets after the cup tie, and I would suggest that the examinations should be held earlier in the week, possibly during the ordinary working hours.

Mr. J. MITCHELL (Leicester): I should like to make an appeal. All our gasfitters attend evening classes and we pay their fees. We all appreciate very much the work that is being done by those in charge of the evening schools, but we have found that there are many things which the gasfitters do not get at the evening schools. Great strides have been made in the development of gas appliances within the last few years, and it is impossible to give the gasfitters a knowledge of the construction of all the different appliances at the evening classes. We in Leicester have started a miniature Watson House, and have appointed a full-time instructor. The men go through the course there regularly, and I think a great deal more could be done in the various undertakings by such means. Certainly it cost something; it cost us about £500 to get it together, but we feel that it is well worth while. People are actually complimenting the department on the class of work and on the way in which it is carried out.

Mr. TERRACE: Starting from the plea made by Mr. Briggs that this meeting should be used by the members of the Institution as their opportunity to express their opinions on the education scheme, I want to say that this year I invited the Chairmen of all the district education committees to take part in the discussion. I am very pleased indeed by the discussion we have had this afternoon; but I want to say one thing about the remarks of my old friend, Mr. Madden, who has been with me right from the early days of the education scheme. I hope you will not take too literally what he has said about the District Committees not meeting very often, or about their being very off-hand in their work, because at the meetings of our Education Committee we have regularly the minutes from several of the district education committees, and I can assure you that they are very live bodies.

The other points which have been mentioned during the meeting to-day have been noted, and will have the very careful attention of the Education Committee.

The Production of Free-Burning Coke in Continuous Vertical Retorts

Communication No. 199

by

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[ABSTRACT]

Further co-operative research work between the Edinburgh Corporation Gas Department and the Fuel Research Station has been carried out at the Granton Works of the Corporation. This Paper describes experiments upon the production of smokeless fuels for domestic purposes, using the plant and methods of gas manufacture in continuous vertical retorts.

The known reactivity of the coke made from weakly-caking coals was utilized by making a careful choice from Fuel Research Station survey records. The temperature of carbonization normal to gas manufacture was reduced so that the coke was not heated for any length of time above 700° C. This was achieved with sized coal (doubles or trebles or mixtures of these) while maintaining the throughput of coal usual with Scottish gas coals. The yield of gas was, however, reduced to 52 to 60 therms at 13 per cent. steam or about 25 per cent. below the Edinburgh yield for 1937; this gas has, however, appreciably higher calorific value.

Eighteen coals were examined at the Fuel Research Station and five were selected for full-scale trial at Granton. These were drawn from four of the Scottish coal-fields. Coals of this type, having carbon contents of about 82 per cent. and varying in Gray-Campredon caking index from < 5 to 12 are available in many coal-fields and further exploration would indicate a very large reserve of coal. The carbonization experiments were carried out at Granton on a setting of four Woodall-Duckham continuous vertical retorts which form part of a larger bench. The setting is specially equipped with its own collecting system and facilities for measuring and sampling. The conditions on the retorts were stabilized on each coal and complete measurements taken during test periods of 2 to 3 days' duration. No difficulties of any kind were experienced.

The five coals gave approximately the same yields of products. The slight caking power of the coals resulted in each case in slight agglomeration and swelling, so that the mean size of the coke was higher than that of the coal.

	Coal.	Coke.
Over 1½ in. .. per cent.	12·5	32·0
1½ in. to 1 in. .. „ „	42·3	36·7
1 in. to ½ in. .. „ „	26·2	12·3
Through ½ in. .. „ „	19·2	18·8

The yield of gas varied from 10,000 to 12,000 cu.ft. or 52 to 60 therms per ton of coal at about 520 B.Th.U. per cu.ft., as compared with 16,000 cu.ft. and 73 to 84 therms at 475

TABLE 1.—*Results of Carbonization Experiments*

Coal		A	B	C	D	E	Edinburgh 1937.
1		2	3	4	5	6	7
Temperature of chambers	°C.	1,195	1,204	1,203	1,205	1,206	1,390
Temperature of check tile	°C.	943	959	932	955	935	1,150
Steam, per cent. of coal		18·6	11·5	14·4	13·3	12·1	14·0
Scrubber water,	tons	4·84	5·17	2·53	5·51	4·0	—
	per cent. of coal	5·4	4·8	3·7	5·3	4·0	—
COAL:							
Total carbonized	tons	89·8	108·4	69·2	103·8	99·8	—
Per retort per day	tons	11·22	9·03	8·65	8·65	8·31	8·5
Moisture	per cent.	8·0	8·2	7·2	9·1	7·7	—
Ash	per cent.	3·7	3·0	4·2	5·3	7·1	—
COKE (dry):							
Total produced	tons	58·05	63·58	41·66	56·53	61·07	—
Per ton of coal	cwt.	12·9	11·7	12·05	10·15	12·25	13·1
Volatile matter	per cent.	4·0	4·0	6·4	5·1	4·6	1·5
Graded > ¾ in.	per cent.	78·8	86·4	80·4	80·3	80·0	—
GAS:							
Total volume	1,000 cu.ft.	961·2	1,245	726	1,222	1,181	—
Per ton of coal	cu.ft.	10,700	11,490	10,490	11,770	10,950	16,000
	therms	58·45	60·7	52·1	56·0	57·9	76·0
Per retort per day	therms	656	548	496	484	482	—
Specific gravity, air = 1		0·490	0·486	0·512	0·517	0·541	0·475
Calorific value	B.Th.U. per cu.ft.	546	528	496	476	529	476
H_2S in crude gas	gr.	573	529	262	465	390	342
Spirit	gal. per ton	2·46	2·20	1·42	—	—	0·84*
TAR (dry):							
Total produced	gal.	1,637	1,719	1,001	1,692	1,620	—
Per ton of coal	gal.	18·2	15·9	14·5	16·3	16·2	15·4
Specific gravity		1·092	1·098	1·081	1·082	1·080	1·072
LIQUOR:							
Total produced	gal.	6,201	6,820	3,217	6,532	5,900	—
Per ton of coal	gal.	69·1	62·9	46·5	63·0	59·1	38·0
Specific gravity		1·016	1·022	1·021	1·020	1·018	1·020
Ammonia	NH_3 per cent.	1·39	1·59	1·64	1·34	1·40	1·53

* Partial recovery only.

B.Th.U. from Scottish gas coals under normal gas making conditions using continuous vertical retorts. The gas had a calorific value up to 540 B.Th.U. which would offset the lower yield.

The lump coke was tested for combustibility by an empirical fire test using a domestic well grate of the type commonly installed in small houses. Despite the relatively low draught in this type of grate the fuel ignited readily and in some cases burned as well as the standard fuel, a low-temperature coke. Those cokes which were not quite so good as the standard gave very satisfactory performance in a barred grate, also of common type.

The mean gross yield of coke from the coals examined was 12·1 cwt. Of this, 10·5 cwt. were suitable for sale as lump smokeless fuel for the open grate. In addition, 0·6 cwt. were suitable for closed stoves as a grade from ¾ to ¼ in. The fine breeze below ¼ in. would have only slight commercial value unless it were briquetted. The yields are the gross yields and assume that ordinary gas coke would be used as fuel.

It is felt that smoke abatement could be further assisted by the Gas Industry by the manufacture of smokeless fuel in this way. The change in technique would not necessitate any change in plant in Works where continuous vertical retorts were available. Suitable coals should not be difficult to find; they are available in the coal-fields of Scotland, Northumberland and the South Midlands. The manufacture of smokeless fuel could be made the function of standby plant or could provide work for periods of low demand for gas by reducing the gas yield, but in either case the higher price obtainable for the coke would balance the higher coal cost and allow of the production of gas at the same price per therm. The investigation therefore provides a further example of increased flexibility in the processes available in the Gas Industry.

EXPERIMENTAL RESULTS

The main results of the carbonization experiments carried out on the five selected coals are detailed in Table 1. The yields obtained from Scottish gas coal under conditions normal to Edinburgh (gas of 475 B.Th.U.) are included in this table in order to show the general effect of the change of coal and the reduction of carbonization temperatures.

In Table 1 the yields are calculated in terms of coal at the moisture content shown in the table. The yields of coke and tar are calculated in terms of dry products, although as weighed or measured these contained moisture.

Yields and Nature of Smokeless Fuel

Owing to the slight caking properties of the coals some agglomeration of the doubles and trebles took place in the retort, and the mean size of the coke discharged was greater than that of the coal charged. Owing to the fact that the coal had to be passed through the crusher the full size of the doubles and trebles was not utilized. This defect would not arise in manufacture. Although the size of the coal was not originally the same in each case, the passage through the crusher tended to reduce the differences. The size distributions of the cokes were not greatly different. Screen analyses are given in Table 2.

TABLE 2.—*Alteration of Size during Carbonization*

Coal	A		B		C		D		E	
	Coal. D.T.	Coke.	Coal. D.T.	Coke.	Coal. D.	Coke.	Coal. T.	Coke.	Coal. T.	Coke.
1	2	3	4	5	6	7	8	9	10	11
Size Fraction, per cent.:										
Over 2½ in.	0·1	6·5	0·6	7·6	—	5·3	*Nil*	2·3	*Nil*	6·9
2½ to 2 in.	0·4	4·8	0·7	7·9	—	3·8	2·0	3·4	0·9	5·3
2 to 1½ in.	6·5	19·3	9·5	24·1	—	18·9	29·2	25·9	7·1	20·7
1½ to 1 in.	46·3	32·5	46·3	35·9	36·7	39·8	36·9	38·6	55·0	36·7
1 to ¾ in.	27·4	15·7	27·3	10·9	42·3	12·6	8·1	10·1	10·8	10·4
Under ¾ in.	19·3	21·2	15·6	13·6	21·0	19·6	23·8	19·7	26·2	20·0

D, doubles: T, trebles: D.T., doubles and trebles.

Since the coals varied somewhat in size, and since the coke showed agglomeration in every case, it is more instructive to consider the mean increase of size shown by Table 2. This is:

	Coal.	Coke.
Over 2 in. per cent.	0·9	10·8
2 in. to 1½ in. " "	10·5	21·8
1½ in. to 1 in. " "	41·2	36·7
1 in. to ¾ in. " "	21·2	11·9
Under ¾ in. " "	23·2	18·8

The overall effect is therefore the production of a high proportion of pieces between 1 and 2 in., a size which is particularly suitable for the purpose in view.

The tables do not include subdivision below ¼ in. but on the average this "breeze" contained over 50 per cent. of material between ¼ and ¼ in. It is important that this grade should not be classed as breeze since it is particularly suitable for small domestic water-heating stoves and for this purpose could command a fairly high price as soon as a market was

created for it. This has been fully proved in the case of low-temperature smokeless fuels. In the average case, therefore, over 80 per cent. of the coke produced could be sold as lump smokeless fuel and a further 10 per cent. as graded stove fuel. This would leave only 8 to 10 per cent. of fine breeze to be disposed of, but, as even this breeze is free burning, it could be briquetted at a cost of about 3s. per ton (taking pitch at 30s. per ton) and marketed at a price comparable with that of the lump fuel.

In order to assess the value of the lump coke as a smokeless fuel, combustibility tests were made upon it by the Fuel Research Station method. As a smokeless fuel its general appearance was good; it was of a distinctly darker grey appearance than ordinary continuous-vertical-retort coke made at Edinburgh, and the slight caking power of the coal tended to give the pieces a more dense appearance. It is considered that this difference in appearance is important from the sales point of view. If it were to command a higher market price than gas coke it would be necessary that it should be readily distinguishable from it by eye. The bulk density of the fuel was rather lower than that of Edinburgh gas coke. The 1½- to 1-in. grades weighed, respectively, 20 to 23 lb. and 25 lb. per cu.ft., as against 20·5 lb. for Fuel Research Station low-temperature coke and 28 lb. for gas coke from Yorkshire coal.

TABLE 3.—*Combustibility of Smokeless Fuels*

Sample.	Heat Required for Ignition, B.Th.U.	Time Taken to Reach "an "Intense" Fire, Min.	Maximum Rate of Radiation, Heat Units per Min.	Duration of "Intense" Fire, Min.	Amount of Charge Consumed, Per Cent.	Weight of Charge, Lb.
1	2	3	4	5	6	7
Standard coke ..	1,120	56	1·32	80	76	8
Fuel: A	1,850	86	1·24	76	78	8½
A¹	1,230	70	1·23	78	77	8
B	1,510	64	1·58	92	78	7¾
C	1,230	95	1·04	17	72	8¾
D	1,790	92	1·08	54	78	9¼
E	1,680	66	1·24	66	76	8¾
Edinburgh gas coke*	3,900	not reached	0·92	*Nil*	67	9¼

* Volatile matter = 1·5 per cent.
Ash = 7·5 per cent.

The strength of the fuel compares favourably with Fuel Research Station smokeless fuel, and is almost as good as the Edinburgh continuous-vertical-retort gas coke. As regards abrasion, the fuel was much more resistant than Fuel Research Station fuel (91·4 per cent. over ¼ in. as against 79·7 per cent.) and was almost as resistant as the gas coke (92·5 per cent.). This is a very satisfactory indication that there is sufficient caking power in Scottish coals of this type to satisfy both size and strength considerations.

The details of the combustibility tests are shown in Table 3.

Although it cannot be said that the nature of the ash was ideal in any of the fuels, since it was rather light in colour and tended to spoil the appearance of the fire as it burned down, it was not worse than that of normal Scottish house coal. In other districts where brown-ash coal of the right type is available this difficulty would not arise.

Yields of Gas

The reduced temperature of carbonization and the leaving of 4 to 5 per cent. of volatile matter in the coke both necessarily mean a reduced gas yield. From the point of view of the gas engineer this is perhaps a real defect of the process, particularly as it means a low thermal output per retort per day and a corresponding increase of charges such as labour when reckoned per therm of gas produced. There are, however, times when the output of gas in the Works is not the main consideration, and if a market could be established for smokeless fuel produced in this way, the lower yield of gas could be justified during periods when full production of gas was not necessary, particularly if the increased value of the coke discounted the loss of revenue from gas. The production of smokeless fuel at a low gas yield at such times would also tend to avoid the shutting down of reserve plant, and render this more immediately available to take peak loads.

The yields and calorific values of the gas produced have already been given in Table 1.

The coals gave 10,000 to 12,000 cu.ft. of gas per ton or 52 to 60 therms, as against 16,000 cu.ft. and 76 therms from the Scottish gas coals carbonized during 1937 at Edinburgh under normal conditions with about 14 per cent. of steam. In the case of all the coals carbonized, excepting D, the gas had an appreciably higher calorific value than the standard of supply at Edinburgh. This greater calorific value would be valuable for enrichment purposes and would offset in part the decrease of yield of gas of 16 to 24 therms per ton of coal carbonized. Owing to the lower temperature of carbonization the fuel consumption was less than normal. The amounts recorded were of the order of 1·5 cwt. per ton of coal carbonized, but it was felt that the true figure was higher than 1·5 cwt. owing to the drain of heat from the neighbouring setting but was probably less than 2·0 cwt. per ton of coal.

The Barony coal A, which had a rather high caking power, differed appreciably from the other coals in that it was possible to increase the throughput of coal to the very high value of 11·2 tons per retort per day while the mean volatile matter in the coke was about 4·0 per cent. This value was reached after a preliminary run of 8 to 9 days' duration. The high-temperature assay of all the coals dealt with did not indicate any special property of Barony coal which could account for this high throughput, and it must be accepted that a more normal throughput, at the carbonizing temperature adopted, is that represented by coals B to E, namely, 8·5 to 9·0 tons.

ECONOMIC CONSIDERATIONS AND COST

The experiments described in the Paper have shown that it is possible to manufacture in continuous vertical retorts smokeless fuels capable of being burned effectively in the domestic open fire. In order to achieve the desired object it was necessary to introduce two innovations to the normal process of gas manufacture; (*a*) to select and carbonize only those coals suitable in type and size, and (*b*) to reduce the temperature of carbonization appreciably. The success or failure of a scheme such as this must depend primarily upon whether the smokeless fuel produced has a sale value above that of continuous-vertical-retort gas coke. If it has not, the less revenue from the gas would immediately make the process uneconomic.

The best way to view the economic side of the process is therefore to consider at what sale price the smokeless fuel would have to be disposed of to keep the price of gas per therm at the level of normal gas manufacture. In this case the comparison is best made in terms of the costs shown by the Edinburgh Corporation Gas Department, since the experiments were carried out at its Works. The costs for that Department for the year 1937 are included in the first column of Table 4. These show that the net cost of production of gas during that year was 7s. 4·9d. per ton of coal carbonized, or 1·17 pence per therm. In transferring these costs to the

TABLE 4.—*Comparative Costs of Production of Gas Coke and Smokeless Fuel*

Normal Coke, 28s. 6d. per ton ; Breeze, 10s. per ton ; Tar, 2·4d. per gal.
Steam, 1s. 6d. per 1,000 lb.
Smokeless Fuel ; over ¾ in., 36s. per ton ; size ¾ to ¼ in., 30s. Breeze, 5s.

——	Edinburgh : Year 1937.			Smokeless Fuel—Coal B.		
	Quantity.	Cost per Ton. s. d.	Cost per Therm of Gas. d.	Quantity.	Cost per Ton of Coal. s. d.	Cost per Therm of Gas. d.
1	2	3	4	5	6	7
Expenditure:						
Coal	1 ton	20 0	3·16	1 ton	24 6·0	4·84
Producer coke ..	2·68 cwt.	3 9·8	0·60	2·0 cwt.	2 10·2	0·56
Steam	314 lb.	0 5·7	0·08	258 lb.	0 4·6	0·08
Labour	—	1 8·5	0·27	—	1 8·5	0·34
Repairs, maintenance	—	0 10·8	0·14	—	0 10·8	0·18
Total	—	26 10·8	4·25	—	30 4·1	6·00
Revenue:						
Coke over ¾ in. ..	10·11 cwt.	14 4·9	2·27	10·9 cwt.	19 7·4	3·88
Coke ¾ to ¼ in. ..	—	—	—	0·9 cwt.	1 4·2	0·27
Coke under ¾ in. ..	3·02 cwt.	1 6·1	0·24	*0·8 cwt.	0 2·4	0·04
Tar	15·4 gal.	3 1·0	0·49	15·9 gal.	3 2·2	0·63
Benzole	0·84 gal.	0 5·9	0·08	—	—	—
Total	—	19 5·9	3·08	—	24 4·2	4·82
Gas	76·0 therms	7 4·9	1·17	60·7 therms	5 11·9	1·18

* Under ¼ in.

production of smokeless fuels, it has been assumed that the labour and maintenance costs per ton of coal are the same. This is not strictly true, although the throughput is the same in both cases, since maintenance costs might be less at the lower temperature of operation, and coke costs would be increased if additional screening or bagging became necessary. Account is not taken also of the fact that it might be necessary to sell the smokeless fuel in bags, whereas the normal gas coke is sold mainly in bulk. The producer coke is charged as gas coke in order to render the whole yield of smokeless fuel available for sale.

In Table 4 the costs of gas production in Edinburgh during 1937 are compared with those which are calculable from the experimental data obtained from coal B. During 1937 benzole was partly recovered from the gas and this affects the comparison to some extent. The total gas made from coal B is, however, valued as gas still containing the recoverable spirit. Accepting the above reservations regarding the distribution of this smokeless fuel it emerges from this table that the mean cost of gas per therm would not be exceeded if the lump coke were sold at 36s. per ton, the graded breeze at 30s. per ton and the fine breeze at 5s. per ton. Under the heading of coal B the quantities of coke are calculated to 7 per cent. moisture in order to compare them directly with the 1937 results; they therefore differ by 7 per cent. from the yields of dry coke shown in Table 1.

During the experimental work a quantity of the different smokeless fuels made was distributed in the Edinburgh district to people who have considerable experience with smokeless fuels for domestic purposes, and with the exception of coal D (Loanhead) no adverse report was received. In the case of Loanhead an indication was given that the ash content was rather high and on that account the fire did not have the same appearance as that produced by the other fuels. No complaint, however, was made of its ignitability and combustibility, the objection being limited to the nature and quantity of ash. The same objection of high ash was noticeable in the coke from Coal E (Blantyreferme) although in this case it was noteworthy that the forward sample of this coal which was examined at the Fuel Research Station was much more satisfactory in respect to quantity of ash and its colour.

A potential market has already been created in Edinburgh for a fuel of this description and there is no reason to believe that this market will not grow as soon as it is possible to obtain contracts for the necessary quantities of coal; at the present time this is difficult to arrange.

If satisfactory prices for coal can be arranged it is anticipated that the price of gas would be in no way affected if the Edinburgh Corporation was able to obtain the previously noted prices at its Works for the smokeless fuel; if the fines were briquetted the price of solid smokeless fuel could be further reduced.

It has been stated that 3,000 tons of solid smokeless fuel are already imported into Edinburgh annually and retailed at a price of from 60s. to 62s. 6d. per ton. It is felt that the preparation of a smokeless fuel by the method described in this Paper could greatly expand this market by providing an excellent substitute at a lower price. The estimated costs of production show that this price should be acceptable to a high proportion of the domestic consumers.

Mr. JAMES JAMIESON introduced the Paper.

Discussion.

Mr. F. B. RICHARDS (Woodall-Duckham Companies): The Authors are to be congratulated on supplying the answer to a question which must often have exercised the minds of Gas Engineers. The question is this—if there is proved to be a market for an easily ignitable, free burning smokeless fuel, why should the Gas Industry not be the suppliers of this fuel instead of standing by while a new branch of the carbonization industry comes into being?

Mr. Jamieson and Dr. King have shown that the Gas Industry have the means within their power of supplying this need. The novelty of their contribution lies in the fact that to supply the special fuel it is not necessary to spend money to build a plant solely for the purpose. Their recipe is simple. They take any standard high temperature continuous vertical retort, reduce the temperatures by about 200° C.—temperatures still sufficiently high not to cause trouble in silica structures—and then carbonize a selected coal suitable both as regards size and coking index, at a high rate of throughput and under steaming conditions. The resulting smokeless fuel is reported to be entirely suitable, while the gas is of a quality suitable for admixture with normal town gas.

If the demand for the smokeless fuel is reduced or the need for gas increases, then within a few hours the normal high temperature method of operation can be reverted to.

From a purely operating point of view the experimental work described does not call for comment. The research work consisted in finding the suitable coal and the suitable operating conditions.

The selection of the coal is one further example of the great value of the Fuel Research Coal Survey. If there is to be any general application of the methods described in the present Paper, the work of the Survey, supplemented by that personal advice so freely available at all times to enquirers, will be most helpful in suggesting suitable coals for different geographical locations. By means of this information, a list of suitable coals was made available to the Authors. They point out that they sought a coal which did not give a secondary cell structure when coked but which had sufficient caking power to form coherent coke. They further sought this in the size of doubles or trebles. In other words, based upon their knowledge of coal blending they sought to find a coal which might be termed "Nature's Ideal Briquette." It is noted that the caking properties of the coals used are expressed in terms of "caking index." It would be of interest to know the crucible swelling numbers of these coals.

Low-Temperature Fuel from Continuous Verticals.

It must be to many of us an interesting fact that it is possible to obtain a coke with true properties of a low-temperature fuel when operating a continuous vertical retort plant with combustion chamber temperatures of 1,200° C. Success presumably depends upon the regular and rapid descent of the charge through the retort. In addition, the coal must be of such a nature and in such physical condition as to allow rapid heat penetration by reason of the absence of excessive plastic layers and relatively free passage of gases through the charge. By this means is obviated the difficulty encountered by so many workers on this problem—viz., the over-carbonization of the outside of the charge concurrently with under-carbonization of the interior.

Although the recipe appears simple there is no doubt that a satisfactory product will depend upon closely following the instructions.

The Authors' discussion of the economics of the process will be studied with much interest. It emphasizes once again that the production of a smokeless fuel with substantially improved ignitability can only be obtained at an appreciable additional cost per ton. By the methods discussed in the Paper this increased cost may well be less than that of smokeless fuel made in plants specially built for the purpose, with no convenient outlet for gas, involving the establishment of a new organization for production and sales.

Experience shows the necessity of careful and systematic cultivation of the demand for a new product. It shows also how important it is to ensure continuity of supply of an article of uniform quality.

These considerations would seem to have a bearing upon the suggestion of the Authors that the manufacture of smokeless fuel could be made the function of stand-by plant. It would appear that the period of maximum demand for gas would coincide with the period of maximum demand for smokeless fuel. It would appear that stocking of the smokeless fuel in the summer would be necessary to meet the winter demand if the building of plant specially for its production is to be avoided.

Production of "Dryco."

Mr. E. ASTBURY (Liverpool): The production of a combustible domestic coke on a large scale has been a daily routine in Liverpool since 1930; in the early days the fuel was produced from a blend of non-coking and coking coals; later, when the demand increased, the fuel was produced from selected coals under less severe carbonizing conditions in vertical retorts, as is suggested in the Paper. The fuel was

named "Dryco," and the sales increased from 3,000 tons per annum in 1931 to 17,000 tons in 1937. It was considered desirable from the inception to ensure that ease of ignition and combustibility were such that the fuel could be burned satisfactorily in an ordinary well grate. Nottinghamshire coals are used, and the type is indicated by the BSS Agglutinating Value of 14 and Swelling No. 4. The graded "Dryco" has a bulk density of 19-20 lb./cu.ft. and a C.A.B. 0·04.

The Authors find a rather heavy fall in gaseous thermal yield, but the process is not shown to increase the cost per therm; this emphasizes the undesirability of assessing efficiency in "therms per ton;" a properly shaped policy producing a combination of gaseous and solid smokeless therms at low cost is the final measure of efficiency.

In the experiments described the combustion was carried out in downwardly heated retorts, and this was the case in our earlier work. More recently, "Dryco" has been produced in modern upwardly heated retorts, and the greatest care has to be exercised to prevent excessive heat treatment of the coke. Prior to the installation of this type of setting considerable doubt was expressed as to the suitability of this method of heating for this purpose. Further, we have experienced an abnormal failure of the top courses of the retorts leading to complete deterioration of the brick, and the opinion has been expressed that this is due to alternate tar penetration and subsequent carbonization at the relatively low temperature conditions prevailing at that point. It would be interesting to have the views of the Authors and members on the reasons for this failure. The bottom temperatures are maintained at about 1,320° and the top at 1,000°, and the heat treatment of the coke is controlled by the rate of throughput.

The Authors suggest that 4·5 per cent. of volatile matter must remain in the coke. We have found that this is not necessary, and, in fact, is undesirable with the coals which we are using; we require a maximum volatile matter of 3 per cent. The effect of a high volatile content is to increase the combustibility of the fuel, and we have had complaints that fires burned away too quickly and thus shortened the period between replenishments.

Unfortunately, it is difficult to combine ease of ignition with lack of combustibility, but this combination can be attained by increasing the bulk density of the fuel.

We have obtained a fuel of the desired properties by activation with soda ash and lime. A more dense coke is obtained by using a normal coking coal, and the ignitability is retained by the alkali addition. The necessary plant has been installed for a long period test which is being conducted by Mr. Thomas, Chief Chemist to the Liverpool Gas Company, and Mr. Askey, of the I.C.I., to determine the reliability of the process, and the effect on the refractory of the retort.

In this test one bed of four retorts will be producing alkali activated coke, the next bed making "Dryco" fuel, and a third bed ordinary vertical coke. By this means it is hoped to obtain reliable data in order to make comparisons between each kind of fuel—also of the methods of producing them.

There is one point that appears to have been overlooked. In Table 11, giving the comparative costs of production of gas coke and smokeless fuel, no credit has been taken for the extra tonnage of smokeless fuel at 36s. and the reduction in the amount of coke exported at, say, 20s. per ton.

At Liverpool, as the sales of "Dryco" increased—in most cases it replaced coal in the domestic grate—there was a decrease in the tonnage of coke exported—in 1931 17,000 tons exported, 1937 and 1938 *nil*.

I wish to support the Authors' conclusion that the Gas Industry can produce a satisfactory smokeless domestic fuel for use in ordinary well grates with advantage to the undertaking and benefit to the community.

Suitable Coals Not Available.

Mr. R. W. Hunter (Gas Light and Coke Company): I have read this Paper with very great interest because for some time past in several of the works of the Gas Light and Coke Company we have been trying on an experimental scale to produce coke containing more than the normal amount of residual volatile matter and having a degree of combustibility which might make it more acceptable for some of the ordinary coal grates not fitted with facilities for gas ignition. It should perhaps be stated at once that we have met with very much less success than have the Authors of this Paper. The reason for this appears to be that we have not had available on any large scale the particular coals which have been available in Edinburgh, and we have been attempting to achieve success with ordinary Durham gas coal.

The early experiments were carried out in continuous vertical retorts, but these were abandoned some time ago as it appeared to be impossible to obtain an economic yield of a reasonably uniform coke.

More recent experiments have been conducted in horizontal retorts. In this case we do appear to be a little nearer to overcoming the technical difficulties although there is a certain amount of inconvenience during the discharging and quenching of the coke containing the higher proportion of volatile matter.

With the same object—*i.e.*, increasing the reactivity of the coke—we have experimented with the carbonization of blends of coal and pulverized breeze in plant other than continuous vertical retorts. These measures have been attended with some success, but here again there have been technical difficulties and heavy wear and tear costs, so that the economics are not clear at the moment.

Through the courtesy of Mr. Jamieson we have had an opportunity of examining the special fuel produced in Edinburgh and from the tests carried out by Dr. Hollings' staff we can confirm that it is of excellent quality and does fulfil the conditions aimed at by the Authors of the Paper.

The Price Factor.

The economic results of any work of this character will be dependent upon a number of factors, chiefly, the increased price which can be obtained for the new smokeless fuel. The Authors have assumed that they can obtain 36s. per ton when normal coke is selling at 28s. 6d. This differential of 7s. 6d. per ton in the net return for coke at works may be quite a reasonable one to expect in Edinburgh, but it appears to me to be higher than we could hope to obtain in London. Another factor is the cost of the special coals delivered to works. I do not know in what quantities these are available, but we have unfortunately had the experience of special coals mounting rapidly in price as the demand for them became evident.

Another factor to which I would draw attention is that in the event of production on the lines indicated forming a large part of the normal working, the reduction of, say, 25 per cent. in the therm output of the plant would lead to the necessity for replacing this lost capacity, and this seems to me to indicate that the special coke might have to bear something like 2s. per ton for capital charges. In so far as the production was limited and could be met by off peak working this capital charge might not arise, but in such working there would be the necessity for stocking quantities of the coke for sale during the winter. I do not know whether this type of coke would stand the process of stocking, reclaiming, and de-breezing without degradation. I am not clear as to whether the grading given by the Authors was arrived at by the normal process of mechanical screening, or otherwise.

Finally, I would draw attention to the very important paragraph in the Paper where the Authors indicate that they did not consider fuel for special coke grates since these grates already provide a solution to the problem of smoke reduction. It may be that these grates also provide a a solution to the problem of finding a permanent remunerative market for coke and that they will also lead to an increase in gas sales. In London they have proved very popular without any very special sales campaign, and I think that we should keep our attention carefully focused upon them pending the production on a large scale of any new type of fuel such as that which has been brought to our notice by the Authors.

Mr. W. L. Boon (London and Counties Coke Association): If the Authors would not mind my saying so, the meat of their Paper is admirably summarized in the paragraph which reads:

"By these means smokeless fuels which do not require special grates can be manufactured by the Gas Industry without interfering in any way with the normal procedure of gas manufacture and in such a manner that the residuals

can be absorbed in existing markets. The economic success of the method would depend upon the price realized for the smokeless fuel; in Edinburgh the cost of gas per therm would not be increased if the lump smokeless fuel realized a price "ex-works" of 36s. per ton. If an equivalent price were realized there is no reason why the Gas Industry should not apply this technique wherever suitable coals are available and contribute still further, as a solid-fuel industry, in the campaign against smoke."

If the promise made by this statement can be generally realized under practical conditions of gas manufacture then it would appear that we are approaching the production of an ideal coke for domestic purposes, and the domestic market from all points of view is the one which the Gas Industry is well fitted to supply. I regard the commercial aspect of this Paper as a very valuable contribution to the future policy of the Industry in its coke development, and although I offer a few minor criticisms on its technical details I have appreciated its great worth and particularly the benefits it might exercise on the coke side of our Industry.

In the L.C.C.A. we hold the view that the best measure or criterion of the usefulness of a coke in an open fire is the C.A.B. test, which is now officially used by several members of the Association, and which, we believe, although carried out on a very small scale, gives much more reproducible results than any other test which has hitherto been devised. The method of testing cokes adopted at the Fuel Research Station, and widely publicized both in this Paper and many others—for example, their Technical Report No. 46—is difficult to relate to the C.A.B. test, and although the figures quoted in this Paper are useful for comparison among themselves, they cannot be related to the very large body of information which the gas companies, particularly within the Association area, have accumulated on the combustibility of coke.

Accepting for the moment the method used at the Fuel Research Station, it will be seen that the ignition characteristics of these special cokes compare well with those of low temperature coke; while figures given for the number of B.Th.U. required for ignition of gas coke under the same experimental conditions vary round about 3,000 B.Th.U.—that is, twice as much as for the special cokes (Fuel Research Board Paper No. 46). But the rate of pickup of the fires using this special coke does not compare well with that of low temperature coke, and approximates much more closely to figures usually obtained with gas coke. This, to my mind, is a most important point. Moreover, the figure of one heat unit which is used as a standard of intense fire is according to our observations unnecessarily high—that is to say, a fire is useful long before it reaches an emission of one heat unit, and, generally speaking, the times taken to reach one heat unit are more flattering to these special cokes than the times taken to reach, say, half a unit, at which rate of radiation the fires are already quite useful. This is well thought out by the graphs on p. 19, in which the times to a half heat unit for the special cokes are usually more than 50 per cent. longer than those for low temperature coke. This is not to say, of course, that no improvement as compared with normal Edinburgh gas coke is observed. One of the graphs shows that this is most emphatically not the case, but at least according to the Fuel Research Board Paper No. 46, Edinburgh gas coke would not compare well in pickup with the gas cokes used in the preparation of that Report.

Room for Improvement.

Thus, on the evidence of this Paper, there appears to be room for improvement in the pickup of these cokes; but in Hartley and Davidson's Paper they appear to behave almost as well in picking up as do low temperature cokes, so far as can be gathered from the results given for tests in different grates.

It is satisfactory to note that a greater throughput is obtained with this special method of carbonization than with the normal method. It is also interesting to learn that the swelling of the coal gives rise to production from doubles and trebles of a large proportion of coke of size 1 in.-2 in. which, as the Authors point out, is the size most useful for open fires.

The shatter tests of these special cokes are also very satisfactory, since it is a commonplace that ordinary low temperature cokes are undesirably friable and crumbly.

I am sorry that no Northumberland coals were treated, and that no figures are given for the cost of Northumberland coals as compared with the Scottish coals, since at any rate for English use, the Northumberland coals would probably be preferred. If we attempt to relate the table of costs to practice in the South of England, it would have to be accepted that the prices of these special coals would be slightly higher in and around London than in Edinburgh. Accepting, then, a figure of 36s. as being a remunerative ex works price for these special cokes in Edinburgh, a figure of about 38s. would have to be contemplated as being a remunerative ex works price for London. Thus the sales price to the small consumer may have to be between 58s. and 60s. This price approaches very closely that of the widely-sold low temperature cokes, so that these special cokes would have to show some definite advantage over the low temperature cokes for them to be popular. I believe that if their slowness in pick-up were capable of being overcome in any way, they would stand a good chance of being preferred, since they appear to be hard, which low temperature cokes are certainly not, and also on account of their superior ash characteristics. It is an everyday criticism of proprietary low temperature cokes that their ash is fluffy and light; no doubt this is to some extent due to the quality of the coal carbonized, but it is also due to the fact that crushed or slack coal is carbonized, and the banded ash that would be obtained from the carbonization of doubles and trebles would appear to be much less objectionable.

A Large Potential Market.

There is a very large potential market for a first-class low temperature coke in the South of England. One low temperature coke alone sells close on 400,000 tons a year, and is, even so, only touching the fringe of the market. This low temperature coke needs no special grate, a factor which is of prime importance.

It is very largely due to the London and Counties Coke Association that the special grate for burning gas coke has been popularized in this country. We have, over a period of years, advised and been responsible for continuous improvements in the gas coke burning grate, and the present-day product, we believe, is a very good article. There are about 250,000 of these grates in the London area, and this figure is a very large proportion of the total number of grates which we believe to exist in this country. The open domestic coke fire is therefore an important market for our coke already and is steadily growing in value. We intend to continue to push the special coke grate; it is an essential part of our programme, but we are fully conscious of the limitations to its use. In this area, however, there must be something like two million coal-burning grates of all kinds. It is estimated that 85 per cent. of these grates belong to families whose total income is less than £5 per week, to whom the purchase of a coke grate, even on extended payments, costing, say, £3, including installation, is a severe financial strain. Probably most of the coke grates which are installed are in new houses, so that the vast mass of existing coal grates remains untouched, and thus the opportunity of extending the use of coke for open fires, on a scale which we would wish, is restricted, since gas coke as we yet know it only burns indifferently in most coal grates. From the point of view, therefore, of spreading the use of coke, we must welcome this experimental work which is being carried on at Edinburgh and wish it the success it deserves.

Mr. W. R. Branson (Cardiff): The Authors of this Paper are to be congratulated not only on placing before us an example of the possibilities of practical co-operation between a research organization and a gas undertaking, but also upon the pertinacity with which they are endeavouring to widen the range of coals which may be carbonized with profit. I refer to the fact that this Paper follows one by the same Authors presented to this Institution some two or three years ago on the carbonization of Scottish cannel. There can be little doubt that a readily combustible fuel can be prepared in steamed vertical retorts by the methods outlined in the Paper and while this fuel does not appear to be quite as satisfactory as a standard low-temperature coke, as seen by the curves in Figure 1, provided the ash content is low as in

the case of the cokes from coals A and B it should command a price as high as a good quality household coal. The problem is thus an economic one. The costs of production are considered in Table 2. This table presents the kernel of the matter and I propose therefore to confine my remarks to it. The table is based upon the assumption that provided gas is produced at no greater cost than by normal methods, the production of this medium-temperature coke is worth while. In my view unless the cost of gas production can be reduced by the modifications of the carbonization process proposed, it is not a sound proposition. Otherwise, a position will arise in which the gas undertaking is virtually a coal merchant purchasing solid fuel in bulk and retailing it to domestic consumers without profit. The value placed upon the medium-temperature coke—namely, 36s.—represents, therefore, a minimum figure, and unless the actual price received is in excess of this, its production does not seem worth while, involving as it does some complication of the coke handling and selling arrangements if it is to be accompanied by the simultaneous production of normal high-temperature coke.

There are one or two other points in this table which I should be glad if the Authors would clarify in their reply. Firstly, the prices quoted for the two cokes (high- and medium-temperature) are, I take it, *ex* retort house, and make no allowance for the cost of cutting, screening, storing, debreezing, and loading into bags or trucks. I should be glad to have this confirmed. Secondly, the Authors suggest that a grade of the medium-temperature coke between ¾ in. and ¼ in. should have a value of 30s., presumably again *ex* retort house, for use in closed stoves, but they make no similar credit for the normal high-temperature working. I should have anticipated that the more reactive fuel would have been worth, for such purposes, less than a high-temperature coke of similar grade not only on account of the higher flue loss accompanying its higher reactivity but also because of its lower bulk density.

Lastly, attention should be drawn to the very small proportion of fuel through ¼ in. which was obtained in tests on coal B and used in the calculation of this table. This amounts to only 13·5 per cent. of the coke made, is considerably less than any of the other coals tested, and compares with 23 per cent. obtained in 1937 with normal working. One would have anticipated the use of weakly coking coals to lead to a breeze production at least as great as with Scottish gas coal, and I should like to ask the Authors whether they are satisfied that an adequate allowance has been made for breeze produced in grading and in handling into and out of hoppers and storage heaps. The 1½-in. shatter index of the coke from coal A is the only one given in the Paper and it will be seen from Table 6 that this is rather less than that of either low-temperature or normal Edinburgh coke though its abradability is less than low-temperature coke. Shatter and abrasion tests of the other cokes would be of interest.

Not Applicable to Small Works.

Mr. H. G. RITCHIE (Falkirk): The Paper presented by Mr. Jamieson and Dr. King is to be commended as an endeavour to facilitate the sale of coke. The Authors' suggestion that the manufacture of smokeless fuel could be made the function of stand-by plant would not be applicable to the medium or smaller works, especially where the output of gas is not subject to sudden increases due to fog or any other cause. In my own case we have a stand-by setting for short periods only. The fuel could be made during such periods and stored, but as it would be advisable to store it under cover, this would add to the cost of production.

Instead of reducing the temperature of the retort and keeping up the normal throughput of coal in order to increase the volatile matter in the coke, could the Authors say if it would be possible to achieve this by keeping the retorts at the normal temperature and speeding up the coke extractors, thus increasing the throughput of coal? The make of gas per retort is reduced and higher quality gas produced, and in the absence of a water gas plant, the coal throughput of the retorts making ordinary coke would have to be reduced, and probably heavier steaming resorted to, in order to bring the mixed gases down to the declared calorific value. In either case higher grade gas would be made in the retorts making smokeless fuel, but the increased make of gas per retort, by speeding up the retorts, would compensate for the decreased output per retort on those making ordinary coke, the extractor speed of which, I suggest, would require to be reduced if water gas plant is not available. It would be more costly to use extra retorts to make up for the decreased make of gas per retort than to empty the coke chamber more frequently, as would have to be done if the passage of coal through the retort were speeded up.

I hope Mr. Jamieson is not too optimistic about being able to get suitable coal. I think the ash content will be troublesome. There seems to be a mistake on p. 18 of the Report, where the ash in the smokeless fuel is given as 4·5 per cent. when coal A was used, as on p. 14 the ash in coal is stated as 3·7 per cent. The ash should work out at about 5·4 per cent. In the first Report of the Scottish National Development Council "Oil from Coal" Committee which dealt with low temperature carbonization as a source for oil, the Committee state: "Our opinion is that if the new fuel is to make real headway in Scotland, the ash must be kept down below limits depending on the physical condition of the coal carbonized." They state the limit at 4·5 per cent. in the semi-coke (or rather more than 3 per cent. in the coal); these conditions were to be obtained by re-washing the coal. The Authors refer to the accumulation of whitish ash on the surface of the coke after it has burned for a time. This is similar to the findings of the Committee to which I have referred. I was a member of this Committee, and we each tested samples of six different fuels in our homes or offices, and found the fluffy ash adhering to the fuel in almost every case although the colour of the ash was brown. Some of the comments on it were—

> "Beautiful after properly ignited, but unattractive when it dies down."
>
> "Cheerless untidy fire."
>
> "Soon becomes untidy and cheerless."

However, I think the fuel could be sold at a much lower price than low temperature fuel is sold at in Edinburgh now and show a better return for coke in the balance sheet. It might be difficult to find a market for this new fuel, but Edinburgh should have no difficulty in obtaining a price equal to or slightly under that paid for good house coal, provided they get supplies of low ash coal.

It is extremely fortunate for us that Edinburgh have such a large scale experimental plant at their disposal and we are indebted to them for publishing the results in this Report.

Alkalization of Coals in Birmingham.

Mr. T. F. E. RHEAD (Birmingham): Mention has been made of the alkalization of coals in Liverpool. In Birmingham we have been carrying out some very interesting experiments on similar lines, combining with ordinary run of retort coal, crushed to the usual size, 1 per cent. of lime and 1½ per cent. of sodium carbonate, and we have had some very striking results in the effect of the shrinkage on the coal. We had one particular retort which would not work at all. It would not even work with graded coke and when we put the mixture in with fairly good Yorkshire coal, the mixture of alkalis worked satisfactorily. It was quite a surprise although we did know that sodium carbonate caused shrinkage in coke. Incidentally, we formed a very high opinion of the possibilities of such coke in the open grate and I think we can safely say that it had no deleterious effect on the thermal yield. I want to be very cautious in saying it but there were indications that it improved the thermal yield.

Dr. J. G. KING (Fuel Research Station): I would like first of all to thank all those who have taken part in this most interesting discussion. Their contributions are most helpful and most encouraging. There is not time now to reply in detail to the points which have been raised. These will be dealt with in the usual way in writing but there are certain things I should like to say now about my collaboration with Mr. Jamieson and about the Paper. As you know, the idea of collaboration of this type was conceived by the Director of Fuel Research in discussions with Mr. Jamieson some years ago and that it has proved fruitful is a matter of considerable gratification to me and to the Department, and, I hope, to the Institution also. The arrangement stands as one example of the help which the Fuel Research Station is anxious to give to the Institution and to the Industry. I wish

also to pay a tribute to Mr. Jamieson, as a collaborator, on his keenness and enterprise in work of this kind. Collaboration between two people so far apart as we are is not easy, as the thickness of our letter files no doubt testifies, but Mr. Jamieson certainly makes an excellent colleague in work of this type.

Regarding the Paper, Mr. Richards has put his finger on what I would consider to be one of the most important aspects. Mr. Rhead has referred to it also, and that is the value of the fuel research coal survey in showing exactly where coals having specific properties can be found. Without the knowledge gained in this way the problem would undoubtedly have been more difficult. It is greatly to be hoped that other people and other interests who have coal problems of this type will also make use of the detailed information which is gradually being collected in our Survey Department. The knowledge has been most useful in even other ways than these and I should like to give you one example. We have found that active carbon suitable for gas respirators can be produced directly from sized coals, the deciding factor in this case being again the type of coal. Without the knowledge collected by the Survey, the finding of suitable coals for this purpose would have been delayed for a very much longer time.

The second point I would like to make is the nature of the coal itself. Mr. Richards has referred to this also in asking for the W.-D. swelling indices. We did not quote these numbers since this test is more usually applied to gas coals, and these coals are a little outside that range. The actual figures are 2-3 for coals B, D and E, 3-4 for coal A and zero for coal C. The point I wish to make is that by using such coals we are extending the scope of the coals used in the Gas Industry and possibly saving highly caking coals for other purposes for which they are more required.

A final point which has not been very much touched upon to-day is atmospheric purification. I do not say atmospheric pollution. If the open domestic grate is to remain with us, surely the Gas Industry can also be a smokeless fuel industry. It may also supply solid smokeless fuel which is reactive enough to replace coal directly. Certainly, special domestic grates will serve their purpose but the Authors both feel that the open domestic grate without any special appliances and no increase of price, can also be made an excellent instrument in atmospheric purification.

Some Results Attained with Solid Fuels Used in Open Grates for Heating Living Rooms

by

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Communication No. 200

[ABSTRACT]

The object of this Paper is to place before The Institution of Gas Engineers some of the results attained during the last two years in the examination of the behaviour in open grates of a number of solid fuels. These include both coking and non-coking bituminous coals, steam coals, anthracites, high- and low-temperature cokes, and pitch coke. It is hoped that the experience recorded will prove of value in view of its bearing on the production of good domestic coke, as well as on the economic aspect of the problem of room heating, a matter of first importance when considering the best directions for the technical development of the Gas Industry in the future.

For the comparison of the performance of the fuels tested, open grates were used of a type most suitable for their burning.

With the various solid fuels examined, the highest radiant efficiency was attained with gas works coke, which also proved the most economical to use. In the case of the cokes and coals, the efficiency is found to be unaffected by the rate at which the fuel is burned, when the grate is kept full. With the coke grate, however, if it be only partly filled, there may result a marked falling off in the radiant efficiency recorded. What is perhaps more important still is that the radiant efficiency attained with the grates used is uninfluenced by increase in the chimney pull, a factor of importance when considering the relative merits of solid and other fuels.

A good domestic bituminous coal can be kindled readily, giving a fire of pleasing appearance which burns up quickly after re-fuelling. The grates in the majority of houses are designed for use with coal, and, despite the objections and inconveniences of the fuel, it is still the most popular in this country. Estimates as to the quantity of coal used domestically vary very considerably, but it is thought still to amount to some 25 to 30 mill. tons a year. Anthracites and steam coals are little employed in open grates. When so used they yield a higher radiant efficiency than is attained with bituminous coals, and, owing to their high bulk density, enable a fire to be maintained for long periods without attention. Anthracite, of course, burns smokelessly.

The low-temperature coke examined yielded an appreciably lower efficiency than is attained with gas coke. It has a low bulk density, and its real advantage is a result of its high combustibility.

The use of pitch coke led to the production of a fire of very pleasing appearance. The material burns readily, is practically ash-free, and yields a radiant efficiency as high as that attained with any of the other fuels, including gas coke.

The results attained with seven of the gas cokes which were examined are summarized in Table 1, which should be consulted for details. The Authors' experience with some of the vertical retort cokes has been very satisfactory, and has convinced them that if the Gas Industry will take the necessary steps to make available for the public, as it can do, a good coke of uniform quality, a very considerable demand will be experienced.

The principal aim of the Gas Industry is to popularize the use of smokeless fuels for all domestic purposes. It produces annually some 300,000 mill. cu.ft. of gas, of which about two-thirds is used for domestic purposes, and, in addition, manufactures over 12 mill. tons of coke, of which roughly two-thirds is absorbed by the home market, and of this half is thought to be used for domestic purposes. Thus town gas and gas coke are much the principal competitors of raw coal in the domestic heating field.

Properties Desirable in Cokes Intended for Use in Open Coke Grates

(*a*) *Combustibility.*—High combustibility, *i.e.*, a low critical air blast value, is desirable.

The rate of kindling should be such that, in a 16 in. grate, the fuel can be ignited with 15 cu.ft. of 500 B.Th.U. gas, and give a fire radiating energy at the rate of 6,000 B.Th.U. per hr. after a period not exceeding 40 min. from the time of

TABLE 1.—*Results of Open Grate Tests with Various Types of Fuel*

Test No.	Fuel.	Size of Fuel In.	Grate Used.	Weight of Fuel Charges Lb.	Cu.Ft. of Gas or Lb. of Wood for Ignition.	Min. to attain Radiation of 6,000 B.Th.U. per Hr.		Intensity of Radiation at Time of Refuelling, B.Th.U. per Hr.	Average Rate of Burning During Period of "Useful" Fire, Lb. per Hr.	Unburned Fuel in Grate, Lb.	Fuel Loss in Ashpit, Per Cent. Fuel Burned.	Period of "Useful" Fire, Hr.	Gross Overall Radiant Efficiency, Per Cent.
						When Kindling.	After Refuelling.						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Coke No. 1	1 to 1½	Coke Grate No. 1	11.7 and 9·1	20 cu.ft.	55	32	7,000	2·3	1·7	6	7·7	34·0
2	2	½ „ 2½	„ „	11·1 „ 9·0	20 „	70	44	7,000	2·4	1·2	5	6·7	32·5
3	2	1 „ 1½	„ „	10·3 „ 8·7	20 „	55	44	7,000	2·4	1·0	5	6·7	33·7
4	3	½ „ 2½	„ „	9·0 „ 6·3	16 „	57	26	7,000	2·3	1·5	2	5·3	34·7
5	3	1 „ 1½	„ „	8·9 „ 6·6	16 „	50	27	7,000	2·3	1·2	3	5·6	33·9
6	4	½ „ 2½	„ „	8·8 „ 7·0	16 „	46	25	7,000	2·4	0·7	6	5·4	33·6
7	4	1 „ 1½	„ „	9·2 „ 7·3	16 „	42	25	7,000	2·5	0·5	5	5·6	33·0
8	5	½ „ 2½	„ „	9·0 „ 5·7	16 „	45	26	7,000	2·5	2·6	4	4·8	31·6
9	5	1 „ 1½	„ „	9·0 „ 6·2	16 „	39	20	7,000	2·4	2·1	5	5·3	33·6
10	6	½ „ 2½	„ „	9·4 „ 7·4	16 „	39	27	7,000	2·4	0·9	2	5·5	32·9
11	6	1 „ 1½	„ „	8·7 „ 7·7	16 „	38	23	7,000	2·4	0·7	2	5·8	34·7
12	7	1 „ 2	„ „	7·9 „ 6·8	16 „	40	25	6,000	2·5	0·8	6	5·7	32·3
13	7	1 „ 1½	„ „	7·6 „ 7·0	16 „	42	25	6,000	2·6	0·5	5	5·5	32·8
14	Pitch Coke No. 8	1 „ 3	Coke grate No. 1 fitted with more closely spaced bars	8·0 „ 5·9	10 „	24	13	9,000	3·1	1·7	7	4·0	29·8
15	8	1 „ 1½		8·9 „ 7·0	10 „	24	15	9,000	3·2	1·6	6	4·9	28·6
16	Low-temperature Coke	½ „ 3		8·4 „ 5·8	10 „	25	11	9,000	2·9	0·6	2	4·1	27·4
17	Anthracite No. 10	1 „ 2½		18·9	30 „	65	—	—	2·2	4·4	11	6·5	28·0
18	10	1 „ 1½		18·6	25 „	65	—	—	2·1	3·7	12	5·9	30·0
19	11	1 „ 2½		17·3	20 „	55	—	—	2·3	4·8	12	4·6	26·2
20	12	1 „ 2½		17·0	25 „	55	—	—	2·2	4·1	11	5·8	28·7
21	Steam coal No. 13	1 „ 3		18·5	16 „	51	—	—	2·4	2·7	14	5·4	25·6
22	14	1 „ 2½		17·6	25 „	57	—	—	3·2	2·2	11	4·9	28·1
23	15	1 „ 2½		15·0	25 „	65	—	—	2·6	2·0	6	4·7	28·9
24	Bituminous Coal No. 16	1 „ 3	Barless stool Grate No 1	8 + 5 + 5	½ lb.	40	20	6,000	2·6	0·3	1	6·4	26·5
25	17	1 „ 3		8 + 5 + 5	½ lb.	—	11	6,000	2·0	1·2	3	8·3	26·8

lighting the gas burner. To attain this kindling rate, the Critical Air Blast value (C.A.B. test)* should be less than 0·060 cu.ft. per min. for cokes of a bulk density greater than 25 lb. per cu.ft. and less than 0·065 cu.ft. per min. for cokes of lower bulk density. The combustibility of the coke will depend on the type of coal used and the conditions of carbonizing.†

The blending of coking with semi- and non-coking coals frequently increases the combustibility of the coke produced. Considerable reductions of the C.A.B. value for the coke produced have also been attained by blending the coals before carbonization, with activators such as a mixture of calcium carbonate and sodium carbonate.

(*b*) *Purity.*—The importance of the purity of the coke is well known. The moisture content should be just sufficient to fix the dust, that is about 2 to 3 per cent., and should in no case exceed 5 per cent. The percentage yield of ash should be low, and this should be as dense and coarse as possible. The detrimental effect on the appearance and performance of the fire of a finely-divided ash of low density cannot be too greatly stressed.

(*c*) *Grading.*—The optimum grading of the coke will vary with the combustibility of the fuel:

(i) Cokes having a C.A.B. value in excess of 0·065 cu.ft. per min. should be closely graded between 1 in. and 1½ in.

(ii) Cokes having a C.A.B. value between 0·055 and 0·065 cu.ft. per min., such as typical continuous vertical retort cokes, should be graded between 1 in. and 2 in., and contain approximately equal proportions of the 1 to 1½ in. and 1½ to 2 in. grades.

(iii) Cokes having a C.A.B. value less than 0·055 cu.ft. per min. may have wider limits of size, and a 1 to 3 in. grade has generally proved satisfactory. It is not desirable to increase the upper limit of size beyond 3 in., since difficulty will be experienced in maintaining a uniform grading in all supplies, on account of the segregation which will occur in the storage bins, etc.

(*d*) *Bulk Density.*—High bulk density is, of itself, advantageous in the case of an open grate fuel, since the period during which the fire will burn unattended is directly influenced by this property.

(*e*) *Uniformity.*—It is of the utmost importance that the Gas Undertaking maintain uniformity in its domestic coke supplies. If the combustibility or other properties vary appreciably from consignment to consignment, the supplies will need different treatment to give the best results, and the user will experience difficulty in attaining the effects desired.

When considering the possibility of ousting coal from the position it holds at present as an open grate fuel, a number of factors have to be taken into consideration, among which may be enumerated the following:

(i) The cost of providing the necessary thermal energy.

(ii) The psychological effect of the solid fuel fire, arising from the variation of its appearance from hour to hour and the presence of flames, coupled with the sense of satisfaction which some people feel when they have been able, by their own effort, to produce a brightly burning fire.

(iii) The credit or debit which will be made by the consumer using a fluid or a solid fuel respectively, consequent upon the absence or presence of ashes and the need for storage.

In considering the case for gas, its advocates may feel justified in making an allowance for the ancillary advantages which the gaseous fuel offers, and although most people will consider that these are of first importance, both from the wider national point of view as well as from that of the individual householder, it is difficult to assess in terms of cash the value of these advantages. The value placed on the convenience will vary with different households, and as the majority have small incomes* they can little afford to pay for personal conveniences, as the greater part of their income is required for the provision of necessities. Yet it is these people with small incomes who are responsible for most of the consumption of the 25 to 30 mill. tons of coal to which reference has been made already.

It was not the original intention of the Authors to consider the relative costs of heating living rooms by gas and solid fuel, but in view of the number of discussions they have had with other technical members of the Gas Industry, they have

* Blayden, H. E., Noble, W., and Riley, H. L. "A Simple Laboratory Method for the Assessment of the Combustible Nature of Coke." *J. Inst. Fuel*, 1934, 7. 139.

† It was shown by W. Davidson ("The Production and Performance of Domestic Coke," *Gas J.*, 1937, **218**, 211) that the size of the coal and the temperature of carbonization had each a pronounced effect on the combustibility of the coke produced. A highly combustible coke was obtained by carbonizing the uncrushed double (1 to 2 in.) or treble (2 to 3 in) nuts of three typical coking coals in 14 in. coke ovens, using a flue temperature of 1,000° C. and a coking period of 17 hr. These cokes were more combustible than that made from the corresponding 0 to 3 in. coal when crushed to 0 to ½ in., while that made from 0 to 3 in. uncrushed coal possessed the lowest combustibility. The combustibility of the coke was shown to decrease with increase in the temperature and of the period of carbonization.

* It is estimated that over 85 per cent. of the incomes in this country do not exceed £5 per week.

included Section VI, dealing with the relative costs of heating with the various fuels when open fires are used. The deductions they have made from their tests have led them to the conclusion that, so far as the majority of the community is concerned, it would be most economic to use coke. There is little immediate prospect of supplying town gas for domestic purposes at a price which will make it cheaper to use than coke for the heating of living rooms. For the London area, gas at 4d. per therm should prove more economic to use even for long periods in a good design of hearth-type gas fire, than coal in the ordinary open grate.

Summary of the Tests made with Solid Fuels

The results recorded are subdivided as follow:

Section II.—Examination of the open grate performance of various types of solid fuels operating under controlled chimney pull.

Section III.—The effect of chimney pull on the performance of an open coke grate.

Section IV.—The effect of the grading of the fuel on its performance in an open grate.

Section V.—The effect of rate of burning on the radiant efficiency attained with cokes and coals when used for long and short periods.

RELATIVE COSTS OF HEATING BY GAS, COAL AND COKE USING A GAS FIRE OF THE HEARTH TYPE AND OPEN SOLID FUEL FIRES

It is not possible, using only the results of laboratory efficiency tests, to make a close comparison of the fuel costs which will be incurred when coal, coke and gas respectively are used for room heating, as in actual practice much may depend on the care exercised by the user to avoid waste. The gas fire is much the easier to regulate, and will probably be used more effectively than the solid fuel fire, but the cash value of this advantage cannot readily be assessed. The comparison which follows thus involves the assumption that each type of appliance is used as effectively as in the laboratory.

Coal and Coke Fires

The results of the calculations which have been made for the solid fuel fires are summarized graphically in Figures 1, 2 and 3. These indicate the computed cost in pence per

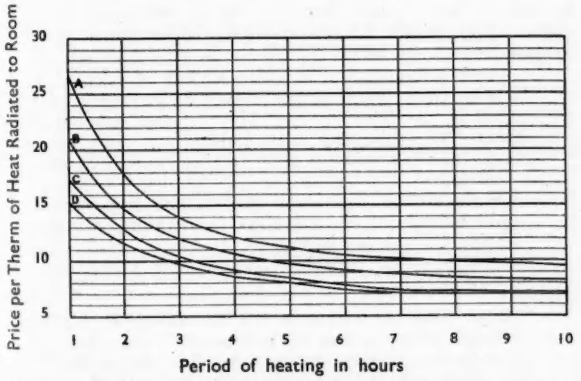


FIGURE 1.—*Cost of Heat Radiated to Room for Various Periods of Heating at Different Outputs with Coke Fire.*

A. 5,000 B.Th.U. per hr. C. 10,000 B.Th.U. per hr.
B. 7,500 " " D. 12,500 " "

therm of the heat radiated to a room for various times of heating at different outputs. The results are based on the period of "useful" fire and on the "floor efficiency," and although the time of occupancy of the room has been assumed to start only when the heat output attains 50 per cent. of its maximum value, the fire is suitably credited with all the heat emitted prior to occupation. The range of heat output covered is from 5,000 to 12,500 B.Th.U. per hr.

It has been remarked previously in discussing the experiments with the 16 in. coke grate that there is little change in the efficiency for long-period tests, when the maximum output is brought down to, say, 8,000 B.Th.U. per hr. irrespective of the size of fuel used, but that at lower outputs there may be a sharp falling off in efficiency if the slower rate of burning is effected by the use of smaller charges of the

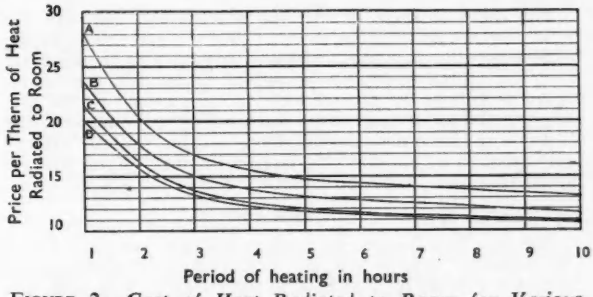


FIGURE 2.—*Cost of Heat Radiated to Room for Various Periods of Heating at Different Outputs with Coal Fire (Coal A).*

A. 5,000 B.Th.U. per hr. C. 10,000 B.Th.U. per hr.
B. 7,500 " " D. 12,500 " "

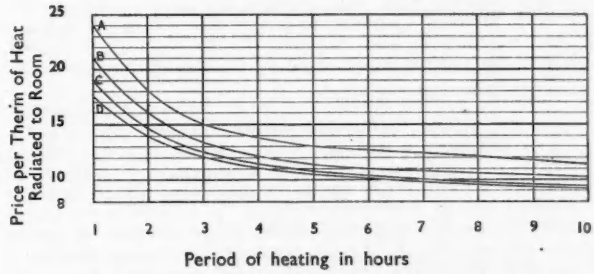


FIGURE 3.—*Cost of Heat Radiated to Room for Various Periods of Heating at Different Outputs with Coal Fire (Coal B).*

A. 5,000 B.Th.U. per hr. C. 10,000 B.Th.U. per hr.
B. 7,500 " " D. 12,500 " "

ordinary 1 to 2 in. size. It is recognized that if the fire were banked with small coke, reduction in the rate of heating could be effected without loss of thermal efficiency, but no allowance has been made for this in the calculations.

Prices of Fuel

The prices assumed for the fuels are those ruling in the London area, and are as follow:

Coke.—Calorific Value .. 13,000 B.Th.U. per lb.
Cost .. .. .. 45s. per ton.
or 1·85 pence per therm.

The price of the gas used for the igniting of the coke fire has been taken throughout at 9d. per therm, so that the cost of kindling is 0·72d. when the grate is completely filled with coke, and 0·63d. for smaller charges, as 16 cu.ft. and 14 cu.ft. of gas are required respectively.

Coal.—Two types of coal are considered:

A. Calorific Value .. .. 11,500 B.Th.U. per lb.
Cost .. .. .. 50s. per ton,
or 2·33 pence per therm.

B. Calorific Value .. .. 13,500 B.Th.U. per lb.
Cost .. .. .. 50s. per ton,
or 1·98 pence per therm.

For the kindling of the coal fires, the cost of the wood is debited at 0·5d.

Results Attained

On examining the graphs showing the cost of the energy delivered to the room, it will be noted that for periods of heating of 1 hr. at outputs of 5,000 and 7,500 B.Th.U. per hr. respectively, and for 2 hr. at 5,000 B.Th.U. per hr. in the case of the 16 in. grates used, coke can offer no advantage in economy

over coal B. At higher outputs and for longer periods of use, the economy of the coke fire is very marked, and grows steadily with increase in the period of heating, as well as with increase in output. For a 5-hr. period of heating, at an average output of 7,500 B.Th.U. per hr., the cost with coal A is 36 per cent. greater, and with coal B 18 per cent. greater than with coke.

The sharp increase in cost for short-period use with the solid fuel fire arises from the fact that the percentage of the total weight of fuel used, which is left burning in the grate after the output has fallen below the 50 per cent. maximum figure, is greater the shorter the "useful period" of the fire. Also, the effect of the charge for kindling, computed on the therm basis, becomes considerable. A 1-hr. "useful" fire is only attained by considerable sacrifice of fuel. Even with an initial charge of 5 lb. the "useful" fire lasted 1·6 hr.

The Gas Fire

The best hearth-types of modern gas fire will yield bench efficiencies of 50 to 54 per cent. over a range of consumptions from 0·5 to 1·25 normal and, as indicated in Appendix I, a "floor efficiency" some two units lower. The influence of chimney pull on the radiant efficiency will depend upon the actual volume of air which is drawn through the flue nozzle. With a given chimney this will be determined by the relative effective areas of the nozzle and of the subsidiary vents, and in any case the total flow through the chimney will be less than is attained with the solid fuel fire which it replaces. The reduction in heat emission due to chimney pull may lead to the attainment of a useful "floor efficiency" some six units lower.

Now the gas fire attains over 90 per cent. of its maximum efficiency within 15 min. of lighting, so that the effective "floor efficiency" will not differ greatly for the varying periods of use which have to be considered. It will not be overstating the case for gas if the calculated cost of the heat radiated by the solid fuel appliance be multiplied by 0·4 in order to compute the price which can be charged for gas to give fuel cost parity. On this basis it is calculated that for a working class home where a fire will be needed during six months of the year, operating at various outputs for daily periods of at least 5 hr. and often up to 12 hr., a coke fire would prove the cheaper in fuel cost even in the London area, unless gas could be sold at an average price not much in excess of 3d. per therm. Gas at 4d. per therm, with which consumers in London are concerned, should prove more economical to use than coal at 2d. per therm.

It must be emphasized that these comparisons are based on the use of an existing type of hearth-pattern gas fire, which transmits practically the whole of its energy to the room in the form of radiant heat. If gas fires are produced with higher overall efficiencies, or, alternatively, if some of the gas is burned in a flueless appliance for background heating, then a higher overall efficiency may be attained. This would make the economic position more favourable when compared with a solid fuel used in the ordinary type of open grate, which is found in the majority of houses. On the other hand, it has to be remembered that there are types of solid fuel self-contained open grates which give higher overall efficiencies as they emit appreciable amounts of energy as convected heat, and also that the prices assumed for the solid fuels are those ruling in London, and are appreciably higher than apply in many important centres in the provinces.

Dr. Harold Hartley presented the report.

Discussion.

Dr. E. W. Smith, who opened the discussion, said: This Paper and the previous one raises again the subject of all-gas *versus* coke, and I am very glad that a firm of such standing and size as Radiation, and a technician of the capacity and size of Dr. Hartley—[Laughter]—should feel, in spite of the controversies that are going on, that there is a great deal to be done in improving the economic side of the Gas Industry by studying coke, notwithstanding that their main interests are in gas. At the same time, I think it is to be deprecated that most of us who are interested in the development of the Industry should leave so much of the development and technique of coke to the London and Counties Coke Association. I feel there is every justification today for The Institution of Gas Engineers itself to co-ordinate all the work now going on in the development of coke and its properties as a whole, quite apart from the work that is going on within the Gas Industry, and I do urge that we as an Industry and as an Institution should take this question of coke seriously. We should work up to the limit the value of our solid material because we have still a long way to go before we can compare the all-gas method with our present methods of gas production.

On the technical side of this Paper I want to raise one or two points which would not have to be raised if there had been that complete co-ordination which I hope will be the case in a very short time. The Authors rightly bring out the importance of coke grading for any particular purpose to which it is going to be put. They also bring out the point that it is important to have, possibly, a different type of grading for each type of coke produced. That is true, and what I want to bring out is that in this work which they have done, and in the Tables in the Report, it would have been an advantage if in the first column of Table 1 there had been no mention of the carbonizing plant in which the coal had been carbonized, because it really has no relevance. The tests were developed with the idea of determining the different radiating values of different cokes of known characteristics. The reason I am making this point is that the cokes which are given for the continuous vertical retort are not typical cokes for that type of retort and the cokes which are given for the intermittent vertical retorts are not typical cokes from such retorts. It is well known that there is greater significance in the source of the coal than in the type of carbonizing plant. Dr. Hartley confuses—and I am using the word very strongly, although I mean it to be very mild—the difference in carbonizing results obtainable with continuous vertical retorts and intermittent vertical retorts and is putting them forward as if they were to be classed in the same category. Those who have both types and have to sell the coke, know that you cannot put them in the same category. There is such a radical difference with the same coals that to class the two cokes as the same is not correct. I suggest it would be useful if we could know more about the actual coals used, as distinct from the plants.

My last point is that I propose to read a few notes that have been prepared for me by someone who is definitely a technical man and yet who wants to put forward the case for coal. I have read these notes two or three times because if we are to have a universal use of coke more than we have had in the past, I think there are one or two points in these notes which should be remembered. The notes are as follows:

> There is one aspect of the question of burning solid fuels in open grates which cannot of necessity be estimated in the laboratory. This is the psychological aspect. The following notes indicate my own personal observations in using a good quality household coal in a well grate.
>
> While paying due deference to the importance of smoke abatement, there are, in my opinion, several outstanding advantages in the use of a good quality house coal which must appeal to the common householder.
>
> (1) *Flexibility in Rate of Combustion.*
>
> By feeding the fire, once it is lit, with either a number of small pieces, a smaller number of large pieces or a combination of these with a banking up of the back with slack, almost any variation in the rate of combustion can be obtained to meet the exigencies of the heating requirements of the room. It is my experience that all carbonized fuels are deficient in this respect.
>
> (2) *Reduced Attention to Fire Feeding.*
>
> Dr. Hartley had given an assessment of the period of "useful" fire. I do not think that this is as important to the ordinary householder as the period between successive stokings of the fire. It is my experience that a coal fire on the average will last from 2-2½ times as long between successive stokings as a carbonized fuel fire. This may seem a small point, but it is a nuisance to the ordinary householder to have to get up and feed the fire every 1½-2 hours, as is necessary with carbonized fuels.
>
> If the room is to be left unattended for any length of time, then in my opinion a solid coal fire is far and

away better than a carbonized fuel fire. For example, last Sunday the fire, after having burnt through, was built up at noon and was not touched until after 6 o'clock in the evening, and the room was at that period almost too warm. Very little coal was used in the remaining four hours.

(3) *Amount of Ashes and Waste Fuel.*

Our experience in changing over from "Coalite," which we burned for three years, to a good quality household coal may be summed up as follows:

That after an ordinary day's running of the fire, the amount of ashes requiring removal from coal is one-quarter to one-third of the bucket. From "Coalite" it is from three-quarters to a bucketful. With coal there is always a bigger proportion of cinders which can be used to make up the next morning's fire than there is with "Coalite."

By judicious feeding of the fire, the whole of the slack produced from a ton of coal can be used in the grate. From 10 cwt. of "Coalite" there was a considerable amount of very fine material which spoilt the fire if attempts were made to burn it in the grate. Generally a considerable amount of fine material had to be thrown away.

It is regrettable that this comparison is not more favourable to carbonized fuels, but it is a summary of our experience in burning "Coalite" for three years and a good quality house coal for the subsequent three years.

Need for Measuring Radiation Efficiency.

Mr. H. J. HODSMAN (Leeds University): Ever since I began the study of the behaviour of solid fuels in the open grate, I have been convinced of the necessity for measuring radiation efficiency in order to make an adequate comparison of different fuels. A measurement of output or relative intensity alone fails to disclose whether a high intensity of radiation is due to high efficiency or merely to a high rate of consumption.

It used to be said that it was not efficiency of radiation which mattered most in the use of solid fuels. It is true that other properties are important. I could, however, never understand why this argument should be advanced by those interested in the sale of gas coke which demonstrably, both theoretically and practically, is the most efficient solid fuel for open fires, once the consumer has equipped himself to take advantage of this property.

I used an adaptation of the Leeds procedure originally devised for testing gas fires, so chosen as to take account of changes of intensity and changes of distribution. The use of the 5-point method described by Bone, Callender, and Yates made it possible to measure these every few minutes. Nevertheless, there was always an element of doubt, which I shared, as to the reliability and precision of the method.

I noted therefore with relief and satisfaction that the Authors, with the superior radiometric equipment designed by Bennett and Hartley, have obtained a series of results which were not merely parallel, but almost concordant with those presented to the Institution in 1933 by Dr. Lloyd and myself. The method we used was undoubtedly laborious, but results appear to be sound.

The efficiency of a fuel for open grates is primarily dependent on its content of fixed carbon, and this is highest in cokes prepared by high-temperature carbonization. Those who equip themselves with suitable appliances can realize the benefit of this efficiency. Those concerned with the sale of coke should be assisted by the Authors' Paper.

A Great Achievement.

Captain J. G. BENNETT (Director of Research, British Coal Utilisation Research Association): I should like to pay tribute to the experimental technique which has been developed in connexion with this radiometer which is able to make a complete traverse and determine the distribution of radiation over a hemisphere in two minutes. That is a very great achievement, and one which the experimenters should be complimented upon by all who have had anything to do with problems of this kind. I cannot, I am afraid, at this point offer in support of the Paper some data of our own work which I should like to do, as this will be included in a Paper which will shortly be presented to the Institute of Fuel. There is, however, a most satisfactory general parallelism in the results, although perhaps we approached the matter more from the point of view of the natural solid fuel than from the carbonized fuel aspect. The main difficulty, of course, comes when comparison has to be made, and I feel there is always a difficulty in that. I should like to go a little farther than even Dr. Smith has suggested and say that those interested in all forms of fuel should get together and agree as to how comparisons should be made. I have in mind the definition of "Useful Fire" in the Paper. The Authors describe this as a convenient method of making comparisons of various fuels. It is very convenient, because it is by this means the Authors on a later page are able to demonstrate that coke is cheaper than coal. The Authors refer to the inequalities of radiation from a coal fire after the "useful" period, as defined in the Paper, is over, but I think that if they were to take the total radiation from the two fires from start to finish, the order of merit would be reversed. Therefore, I feel there is a very definite advantage to be obtained if we could all agree to the method of assessment of these things. I might proceed to read a paper on the relative merits of coal and coke and take the whole radiation during the whole life of the fire and try to prove that coal is better than coke. You would no doubt criticize me, very rightly, for doing so. I think, also, that the comparison which has been based of the rejection of cinders is not necessarily sound, as it is desirable, at any rate when using coal, to use again the cinders from the previous day in lighting the fire. This has many advantages, and therefore to reject these cinders as lost for the purpose of computing the performances is not necessarily the only way of doing it. Here again, I feel that agreement between us all as to how we assess these things would be an advantage.

The main thing I want to say is that my own personal feeling, as one in charge of a research organization concerned with the use of coal, is that coke has a most necessary function. It has the extreme merit, of course, of being a fuel that can be burned smokelessly and it has wonderful merit from the point of view of the combustion engineer in that its combustion can be so beautifully controlled under proper conditions. We ourselves very much favour the use of coke for many types of appliances—*e.g.*, for gravity feeding.

I would like, as an outsider to the Gas Industry, to plead for attention to coke quality. We wish to see more coke used, but we do have cases brought to our notice of cokes, certainly not from the great gas undertakings, but from those of importance, which have caused disappointment in their results when burned in open grates. These cokes have been found to be extremely difficult to light, and I feel that the future of coke would be much brighter if all gas undertakings were to pay as much attention as some do to the quality of the coke they supply for use with open grates.

An Unsatisfactory Standard.

Mr. JOHN ROBERTS: There were one or two points to which exception could be taken, for example: In Table 1, the calorific value of the Welsh Anthracite No. 10 was given as 14,000 B.Th.U./lb. In view of the fact that this coal had the highest carbon content of eight coals given, and its combined ash content and moisture content did not exceed 3·1%, it is remarkable that it should have an appreciably lower calorific value than any of the other coals. Had the value been given as 15,000, it would be more in keeping with the analysis figures.

The Authors regard the period of "useful fire" to start when the emission of radiant heat attains a value equal to half the subsequent maximum. This appears to be an unsatisfactory standard. The standard should be a fixed rate of emission of radiant heat, say, 8,000 B.Th.U. per hour, because obviously such a stage represents really useful radiation, irrespective of the maximum attained during the test.

The third point to be noted is that in the case of the tests with cokes, the sizes adopted were those calculated to give the best results. The same can be said of the weight of the fuel charged, both in the initial stage and the re-fuelling stage. It was therefore not surprising that high efficiencies were obtained with coke. In the case of low-temperature coke, these weights were lower than in the case of the other cokes. The lower weights would give a lower peak, and consequently a lower period of "useful fire" and a lower percentage radiant efficiency. The comparison is there-

fore unsatisfactory. In the case of the anthracite and steam coals, the Authors did not use the correct size of coal, nor did they use the correct weight of charge in any case. The sizes of the fuel used would not be recommended by the speaker for open grates, but preferably cobble sizes, and instead of using an initial charge ranging from 17 to 19 lb. of coal, charges of 11 lb. give very appreciably better results and longer periods of good radiation or "intense" fire conditions.

Tests have been carried out with Welsh coals of the types mentioned in this Paper in six modern grates designed for the use of low-volatile fuels, and in each case the efficiencies attained with Welsh smokeless coals were higher than those obtained with different types of gas coke.

The speaker exhibited his new Radiometer, and by means of lantern slides showed numerous radiation curves obtained with such fuels as semi-coke, gas coke, and Welsh low-volatile coals, burnt in an ordinary semi-well grate. These curves show in a striking manner the remarkably high radiation efficiencies obtained with a 13½% volatile Welsh smokeless coal over ordinary coke, and a well-known semi-coke, exceeding also that of one of the most reactive gas cokes produced in England. I think we ought to qualify some of the conclusions arrived at by the authors.

Commercial Interest was Aroused.

Mr. W. L. Boon (London and Counties Coke Association): My interest in this Paper was immediately awakened by the short paragraph in the summary which reads:

"It is hoped that the experience recorded will prove of value in view of its bearing on the production of good domestic coke, as well as on the economic aspect of the problem of room heating, a matter of first importance when considering the best directions for the technical development of the Gas Industry in the future," and again it is stated: "The Authors' experience with some of the vertical retort cokes has been very satisfactory, and has convinced them that if the Gas Industry will take the necessary steps to make available for the public, as it can do, a good coke of uniform quality, a very considerable demand will be experienced."

These are materially important statements, coming as they do from scientific investigators and based as they are upon technical facts. I have read these paragraphs several times cautiously, to make sure that I should not read into them anything which had not been intended in their framing.

In effect the Authors believe that the Gas Industry can and should improve its coke markets, and that it has at its disposal the ways and means of so doing. My job is coke and you would expect me to support this view, but I should be doing less than my duty if I did not emphasize its importance at this meeting. We are expecting coke to carry a greater share of the Industry's costs than it has carried heretofore, and rightly so, and coke can do this given the will of the Industry to enhance its value to the consumer. I will even be bold enough to say that the economic situation in the Industry *demands* that we should enhance the value of coke.

Do not let us lose the proper perspective in its relation to future gas developments. Coke will be with us for very many years, and we should make a grave mistake if we neglected its development or relaxed our efforts at this time on any promise which the future might hold for gas.

If I have correctly interpreted the views of the Authors of this Paper, they hold similar opinions, arrived at from a totally different angle, and in the previous Paper we have had further evidence on this aspect of coke development if we care to look for it.

The experience we have had within the London and Counties Coke Association with regard to coke utilization and the appliances in which coke is used, prompts me to make a few remarks on this Paper. For instance, it is stated that regarding the comparative performance of the fuels tested, open grates were used of a type *most suitable* for their burning. It would have been very illuminating and interesting for comparative purposes if the performance of fuels in entirely *unsuitable* grates could have been given.

We are reminded of the importance of the purity of coke for open fire burning, and it is stated that the moisture should in no case exceed 5 per cent. I entirely endorse this statement, although I see in Table 1 that the percentage of moisture of some of the cokes tested ran as high as 7·9 per cent. This surely means that there had been too much steaming in the preparation of this coke and that the moisture content was beginning to reach proportions where it was jeopardizing the use of the fuel for open fire purposes.

I should have been pleased also if the Authors had given us some information about the influence of moisture on ignition and pick-ups. The Authors make an important point in relation to the grading of coke, and they draw attention to the fact that the most unreactive cokes require to be most closely graded. For open fire purposes, the most unreactive cokes are horizontal cokes, usually from old retorts, which also may have poor screening plant, so that the moral to be drawn from this would seem to be that the older the retorts the more necessary it is to have an efficient screening plant.

The reference to pitch coke is very interesting, and it will be seen that the efficiency of burning of this fuel compares well with that of the special cokes referred to in Jamieson and King's Paper. It is my view that if full use is made of by-products of pitch coking, pitch coke should be no dearer (60s.) than the special cokes referred to in the previous Paper, and, further, pitch coke presents advantages in C.A.B. value, ash content, and appearance of fire.

I should like to ask the Authors what the effect is of the slide mentioned in the Paper, on the radiation of the fire, and whether they have diagrams with this slide in different positions. In relation to the burning of bituminous coal, the claim made for this fitment seems rather optimistic.

With regard to the distribution of heat emitted by a coke fire, the results given are most interesting, and indicate how misleading the results may be which are obtained from a radiometer placed in a fixed position, such as the determinations which were made by the Fuel Research Station and the Combustion Appliance Manufacturers' Association.

I suggest that a valuable addition to this section would be similar tables for different fuels.

Adaptations to Radiometer.

Captain A. Blackie (Fuel Research Station): First I wish to express my congratulations to the Authors of this interesting Paper on the results that they have now put before us. There is, however, one other subject for congratulations and thanks of all those interested in the testing of solid fuels as burned in open grates, and that is the adaptations made to their radiometer by the Authors which suit it for the measurement of the more fluctuating radiation produced by solid fuels, and the exposition here given of its use in such circumstances. It is not too much to say that the instrument is indispensable to any laboratory where many tests of radiant efficiency of open grates burning solid fuels are required. I can only hope that the increased cost of the modifications is not commensurate with the increased utility of the instrument, and that it will be widely used.

Turning now to the Paper itself, this is so full of interesting matter on almost every page that adequate discussion is impossible in the short time allowed. I will therefore only briefly refer to one or two points on which our experience at the Fuel Research Station has been similar or parallel to that of the Authors.

The effect of chimney pull on radiant efficiency is studied and it is shown that the latter is normally independent of the former. Our experience entirely supports this conclusion, measurements having been made with a wide range of chimney draughts and with both cokes and coals.

On the effect of grading of size of fuel discussed and following, we have made numerous tests with different sized coal graded within the narrow limit of ½ in. In the stool grate used it was found that the different sizes gave very different results for mean intensity of radiation, duration of useful radiation, and for the product of these quantities. A different type of grate used with the same coal sizes again gives different figures. The moral as regards test work is obvious.

I was interested at the note of the appendix regarding the relative effects of brick rubble and slag wool as insulation behind the grate. Similar tests on these two materials were made at Greenwich some time ago. These showed an increase of total radiation of about 9 per cent. for the slag wool insulated fire. Of this about 4 per cent. was due to the higher temperature and heat storage of the grate back and sides and the rest to the higher temperature of the fire itself and greater proportion of fuel consumed. The subject of grate insulation is therefore one, as the Authors have pointed out, which must be seriously considered.

AUTUMN MEETING

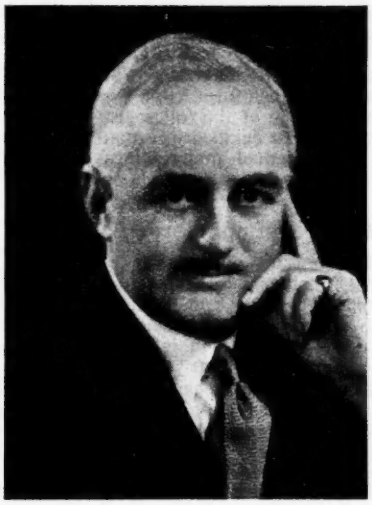
OF THE

Society of British Gas Industries

The Autumn Meeting of the Society of British Gas Industries was held at the May Fair Hotel, W. 1, on Thursday, Nov. 3—Sir FREDERICK WEST presiding in the unavoidable absence of the President, Viscount Ridley.

The first business was to approve the alteration of the title of Section XI. to cover exhausters, boosters, and compressors. Mr. F. H. WILKINSON, in moving the resolution, referred to the changes which had taken place during the last few years as a result of amalgamation and absorption of one gas undertaking by another, the taking of coke oven gas, and the increasing use of gas for industrial purposes, which rendered boosters and compressors essential in most distribution systems. The Council of the Society deemed it advisable, therefore, that the makers of such appliances should be included in one of the Sections, and it was thought that No. XI. was the most suitable. Several of their members were makers of such plant already, and it was felt that if they altered the title of this Section other makers now outside the Society would become members.

The proposition was seconded by Col. O. B. F. PLANCK and carried unanimously.



The Chairman of the Council

An Observer's Viewpoint of the Gas Industry

Chairman's Address

BY

Col. O. B. F. PLANCK, D.S.O., T.D., D.L.

In considering the subject upon which I should address you this afternoon, I realized that it was not by any means obligatory for me to choose one connected with the Industry which the Society of British Gas Industries serves. Nevertheless, I felt that in so far as I was competent to do so, I would prefer to talk about the Gas Industry for the reason that all my listeners, in greater or less degree, are interested in that great Industry. Some of our members dispose of 100% of their products to the Gas Industry, while others have only a partial interest in so far as turnover is concerned. But certainly to all of us, irrespective of our technical or financial interest, the Gas Industry has an important appeal.

I argued with myself that while my immediate predecessors in this Chair have been particularly fitted to address you on a subject connected with the Gas Industry, by reason of their intimate knowledge of the Industry, I could not claim to possess any such detailed inside knowledge as they; but in so far as there may be truth in the old saying that "onlookers see most of the game," I eventually decided to offer you some observations upon the Industry as seen from a viewpoint situated neither within nor without, but upon the fringe.

Still Vast Fields to Conquer.

There can be no question that an observer in the position, as it were, of a traveller who, having climbed the farther slopes of a mountain range, obtains his first view of the new country from that distant eminence, is struck by the magnificence of the terrain before him. He sees in the Gas Industry one which is highly organized, old-established, yet ever ready to embrace new ideas.

I am informed that the number of consumers has reached a record figure of nearly 12 millions; in the last 20 years, gas sales have increased by 20%; the number of gas appliances in use for heating is enormous; there are some 800,000 gas street lamps in this country, representing about two-thirds of the Nation's public lighting, these accounting for an increase of 40% in consumption for that purpose since 1925; an over-all average of some 15% of the gas made is sold for industrial purposes, this proportion being greatly exceeded by certain undertakings; some 4,000 trades make use of gas—a wonderful tribute to the importance of the Industry to the country. I need not detail the valuable by-products that are recovered in the gas-making process—even if I knew the many uses to which these products or their derivatives were put, the space of this whole address would be insufficient to describe them. The Gas Industry is the Coal Industry's biggest customer, being responsible for the employment of nearly 70,000 miners. If we add to this number those employed by gas undertakings and the employees of manufacturers of appliances and plant, we find that over 200,000 people are in work solely because some 18,000,000 tons of coal are carbonized each year in British gas-works. Add to these the numbers engaged in industries making use of by-products, and the total is considerably greater. Already, the capital directly invested in gas undertakings is some £225,000,000, with a revenue of nearly £70,000,000 annually.

The Earl of Dudley, President of the British Gas Federation, concluded his address to the Joint Gas Conference in Birmingham in March last with this significant remark: "Make provision for the future; for the end is not yet and there are still vast fields to conquer." Those who are interested to compare the progress made within the last 33 years, the period of the life of the S.B.G.I.,

will be struck by the changes that have occurred within those years. Candle-power has been displaced by calorific value; the vertical retort has been developed; coke has been promoted from its former status as a rather undesirable by-product to a position almost equal to that of gas, a change which may or may not be permanent, but which is indicative of the new outlook of the Gas Industry as an important section of the fuel industry, and not—as in those days—primarily as a lighting industry; the processes of gas purification have been fundamentally changed and extended, in proof of which it is not necessary for me to do more than point to Sir David Milne-Watson's address to the Fuel Luncheon Club, which was published in the Journal of the Institute of Fuel for August last; high-pressure distribution has become common practice; service to the consumer has been greatly enhanced; a huge industrial gas load, non-existent 33 years ago, has been built up by the aid of industrial development centres that exist to give service and advice to industry; education and improved salesmanship have gone hand-in-hand; the take-it-or-leave-it attitude of the past has disappeared; public lighting by gas has been revolutionized; every public service that can be given by other fuels is given by gas, including that modern miracle of chemical engineering, refrigeration by a gas flame; even as I write these lines I see that an all-gas wireless receiving set is announced; the Industry has been reorganized upon a much broader basis, and there is built up before the observer's gaze a picture of activity, progressive development, and planned organization to which it would be difficult to find a parallel elsewhere.

Having surveyed this panorama, which reflects the very highest credit on all concerned—leaders, staffs, and workpeople—let us descend from the heights and attempt to view things more closely and in more detail.

Competition of the Future.

The tendency in recent years has been for co-operation between the firms engaged in any specific industry to increase, whether or not those firms are in direct competition with each other. By this means, prices can be stabilized, work can be spread economically and in agreed proportions over the industry, and a research organization, sometimes working in conjunction with the Department of Scientific and Industrial Research, can be financed by the particular industry as a whole to investigate the common problems of all for the advantage of all. To my mind, this co-operation in various industries appears likely to increase and to become more and more general. If this be so, unregulated competition within particular industries will tend to disappear; but there must be continual effort to cheapen production and to improve quality by pooling technical knowledge, this being necessary to meet the competition of other materials and goods which will serve the same purpose. To illustrate, there is the competition between steel and concrete in certain fields; in other fields between steel, glass, and plastics; and in many directions between natural products and manufactured products.

The competition of the future may thus be between industries rather than between the several units in any one industry, this being a natural consequence of modern scientific research and rational marketing arrangements. I draw attention to this trend, because it appears that years ago the Gas Industry reached this stage and for a long time has been in a virtually unique position in that all the information possessed by any of its members has been at the disposal of all. This free interchange of ideas has been and is of very great advantage to the Industry, and since each undertaking has its own area of supply, internecine competition is eliminated. It is true that the Gas Industry has competition from other classes of fuels, such as electricity, oil, and raw coal, but in my opinion, provided this competition be kept within reasonable limits, it acts as a useful stimulant to the Industry.

Co-ordination of Research.

The observer cannot fail to be impressed by the amount of research that is being conducted by and within the Industry. Sir David Milne-Watson's address to the Fuel Luncheon Club, to which I have already referred, was a graphic illustration of the virility of the technical research within the Industry and he stated that his Company alone is spending more than £100,000 a year on research. He declared: "I am more than ever convinced that expenditure on research is one of the best forms of insurance for the future expansion of industry. Research is, in truth, the very foundation of our path of progress." In view of the importance of the subject one is tempted to ask whether research in the Gas Industry is organized to the best advantage? There is a large volume of research by individual gas undertakings; a great amount of work by members of the S.B.G.I., though it must be remembered that plant and appliance makers may be justified in wishing to keep private certain of their research efforts and results; the standard researches under the ægis of The Institution of Gas Engineers, and the work of the industrial gas centres. There must be a great deal of overlapping, and it is a moot point how far it is good for each group to work more or less independently of the others. Should we not gain more if we had a single research organization for the whole Industry co-ordinating what has been and is being done, acting as a focal point to the Industry, and assisting everyone by advice based on researches that would be reported to and co-ordinated by a central body?

Lack of Statistical Information.

It is surely impossible to fail to note the lack of statistical information available within the Industry. Such information must be necessary for the formulation of policy, for prestige advertising, sales campaigns, and the like. It is not necessarily suggested that all statistical information should be published, but in an industry free from intercompetition a very complete record surely could and should be kept for internal use in some central office, there to be available to engineers and managers of undertakings, with a section devoted to information which would be helpful for publicity purposes. To enable such statistics to be of the fullest use, surely they should be built upon the most detailed information available from and supplied by individual undertakings, and finally grouped in such a manner that a valuable market survey results.

Training of Engineers.

Then there is the important question of education and training. In perhaps no other industry is it considered so essential for the engineer to have been "through the mill" before taking a high position. The spectacle of such positions going to untrained men through influence is virtually unknown in the Gas Industry. The young engineer must pass his examinations and he must spend years on the works as a junior and as an assistant engineer before he is rewarded with a managership. Sir Frederick West has lately given us in his William Young Memorial lecture interesting details of the extent of knowledge required by the gas engineer and I shall not attempt to add to, nor to improve upon, what he has there said, either in regard to education, or to the problems of remuneration. Sir Frederick has painted an impressive picture in that discourse on the training, qualifications, and work of the gas engineer, and I trust that his words will be studied and acted upon by all connected with the Industry.

The training available in the Gas Industry, however, does not stop at the higher staff; it embraces also the humbler employees who, whether as clerks, as salesmen, or as fitters, serve the Industry. There are many institutions wherein this training may be secured, but as perhaps the peak of them all I need only mention Watson House. The training of the employee there is a model one. Unfortunately, a number of undertakings are not large enough to possess a training centre of their own, but by a system of apprenticeship much, though not all, that is necessary can be achieved. I am aware that in the densely populated centres and large industrial areas the necessary complete syllabus and training are provided, but in outlying and country districts I suggest some further effort—other than the existing correspondence courses—might with advantage be arranged.

Education for Salesmanship.

The fitters and those engaged in gas service are the standard by which the public judges the Industry and those men, in the mass, play an important part in the impression conveyed to the consuming public. The training of the salesmen, too, is important, and there is an evident desire to eliminate what is euphemistically described as a "canvasser," who not infrequently turns out to be a man without any real

knowledge of gas appliances, who goes from door to door leaving behind the impression only that he wants to sell some appliance or other, and with no thought of that great and dignified ideal of service which it is the ambition of all far-seeing leaders of the Industry to impress upon the public. The best gas salesman is he who is engaged within the Industry and who is imbued with this spirit. This thought prompts me to ask whether the Gas Industry makes sufficient use of its own employees as salesmen?

May I, in this connexion, quote from a Paper given by Mr. C. F. Edmondson, General Manager, City of Perth (Australia) Electricity and Gas Department, to the 1937 convention of the Australian Gas Institute? He said: "In 1931 I instituted a sales campaign on a commission basis. As we had both gas and electrical employees and both gas and electrical appliances to sell, it was necessary to get the employees in, in batches of 30 or 40 in the evenings, for lectures on the appliances to be sold. Then we let them loose on their cousins and aunts and close friends, and then on the general public. The results were amazing in more ways than one. A gas foreman sold the electric mains superintendent a nine-radiant gas fire. . . . We gave prizes, selected from our showroom for the most sales in the various groups. . . . In the first three months our employees sold approximately £2,000 worth of appliances. The consumption of gas and electricity by the appliances sold in this campaign did much to stop our falling sales of gas and electricity, and certainly gave a new interest in their jobs to many of our employees; and this interest still continues to-day, after six years, because we still have the scheme running."

Showrooms are not enough to sell gas. It is a far cry from Perth, Australia, to Perth, Scotland, but there is a striking similarity of ideas. Here is an excerpt from the Presidential Address of Mr. A. C. Rea, Manager of the Perth Gas Department, to the Scottish Junior Gas Association this year. "I am convinced that the Gas Industry will have to rely on outside selling to a much greater extent if modern appliances are to be introduced to our consumers at anything approaching a reasonable rate. Our consumers have invested capital in appliances during previous years. They are naturally willing to make these suffice, unless advantages can be offered in modern appliances. These people will not enter a showroom. . . . It is only the outside salesman who can have the opportunity of a talk with this type of consumer who represents the majority. The ordinary canvasser will not do as an outside gas appliance salesman, as we are out to sell gas service by means of modern appliances and not the appliance alone. The salesman must have the interest of the consumer at heart and a sense of responsibility to the undertaking."

Towards an All-Gas House.

Sir David Milne-Watson, in his address to the International Engineering Congress at Glasgow, stressed the ideal of the "All-Gas House" in relation to the cost to the consumer. He showed that at Kensal House a combination of coke and gas heating has met the situation as far as seems possible to-day. The average fuel expenditure of a London working-class house is estimated at between 5s. 6d. and 6s. per week; at Kensal House gas through the slot meter costs 3s. 8d. per week and coke 1s. 7d., a total of 5s. 3d., which by using a two-part tariff in place of slot meters would be reduced to 4s. 4d. Turning over the pages of the Technical Press, one notes that Mr. George Helps, of Nuneaton, Mr. George Braidwood, of Coatbridge, and Mr. T. P. Ridley, of Newcastle, have all equipped houses that burn no solid fuel, the gas being supplied to these houses upon such terms that the total annual cost is no greater than when coal is used for heating and cooking. The technical aspect of the subject lies beyond the scope of this address, and I need only refer to two articles upon the subject by an anonymous writer ("M.Inst.Gas E.") contained in the "GAS JOURNAL" for January 5th and March 16th. The Gas Industry sells some 1,500 million therms annually, from which we may deduct 20% for industrial and lighting loads, leaving 1,200 million therms for domestic use. It has been established that 100 therms of gas are the equivalent in domestic heating use of 1 ton of house coal. On this basis, the Gas Industry supplies *as gas* no more than 12,000,000 tons of coal annually, leaving the possibility of expansion up to another 35,000,000 tons if the All-Gas House could be made generally feasible. The whole social tendency of our generation is in the direction of labour-saving with the elimination of dirt and smoke. The appliance makers have as much to gain from the adoption of this All-Gas House policy as have the gas undertakings. It appears to an observer on the fringe of the Industry that the possibility of giving practical effect to this policy is the greatest single problem—because it is the greatest single opportunity—facing the Industry to-day. It seems, rightly or wrongly, that it is not a problem which should be left to a few isolated engineers and managers, or appliance manufacturers, to experiment upon, but that it should command the attention of a strong body within the Industry set up for the purpose of considering this vital problem and all that it entails. In this connexion, the great importance of the principle of price tariffs must not be overlooked.

Has the Industry a Coke Policy?

No doubt a big increase in the number of All-Gas Houses would entail either the discovery of fresh outlets for coke, or the adoption of manufacturing processes that did not make coke, but the problem is one which the Industry is well equipped to solve. Mention of the All-Gas House brings to my mind the fact that within the Industry there is no concerted policy regarding the co-production of coke and gas, nor is there any agreed article of faith regarding the place of coke in the Industry. It seems as though the Gas and the Coke Oven Industries will presently work together upon coke marketing, but to an impartial observer the whole position is very fluid, and a state of some uncertainty exists as to the position and future of coke within the Gas Industry. There are those who believe that gas undertakings should be suppliers of fuel in the widest sense of the word, and there are those who believe that gas should be the only fuel marketed. Many believe that successful coke marketing opens to gas many doors that would otherwise remain closed; others hold that coke and gas are competitors. Should this divergence of opinion exist, or should the Industry make up its collective mind upon an agreed policy? What is a sound policy?

Retail Prices of Gas Appliances.

There can be no possible doubt that the immense improvement in the character of gas appliances that has occurred within the last 20 years has done much to increase the sales of gas, even though the additional efficiency of these appliances has operated in the first instance in the reverse direction. The higher the efficiency of the appliance, the nearer we approach the possibility of the All-Gas House with its immense potential increase in the sale of gas and appliances. The replacement (not the reconditioning) of obsolete appliances by modern equipment is essential to the retention of, not to mention an increase in, the gas load.

It would appear, however, that a settled policy should be determined throughout the Industry as to the price at which gas appliances are sold to the public. It seems to me it is not good that neighbouring undertakings should quote consumers different prices for the same apparatus. Distrust is engendered and national advertising campaigns are handicapped or rendered impossible. Some gas managers believe in selling appliances at near cost price with the expectation that thereby increased consumption of gas will be secured; others believe that a handsome profit should be made on the sale of the appliance. Which view is right? The cost of carcassing houses as charged to the builder or householder is subject to similar uncertainties.

There also seems need for better arrangements to be made with architects to design all their houses suitable for both gas and electricity. Even if an architect is asked to design an all-electric house, he can never be sure that his client, or the next owner or tenant eventually will not want to install gas appliances. It is on the important question of ventilation that the designers of many modern houses and flats fail to appreciate the problems involved. Whatever be the fuel used for heating and cooking, the primary need of adequate ventilation is of the utmost importance.

Lighting, Public and Domestic.

The concerted efforts of the Industry in connexion with public lighting in recent times, which Mr. R. J. Rogers, my predecessor, reviewed so fully in his address to you last year, have resulted in a notable improvement in the Industry's

competitive position in this field, although I feel the importance of retaining gas street lighting is still not sufficiently realized.

In many quarters there seems to be a defeatist attitude with regard to domestic lighting. Although this is still an important item, the Industry seems disposed to let this load pass to electricity without a struggle. I have no desire to make out a case for one or the other type of illumination, but I suggest that a considered policy should be followed. If it is decided to attempt to retain this domestic lighting load, should not the Industry and the appliance makers combine to investigate the problem of providing apparatus such as will not place gas at the disadvantage it too often occupies in this field to-day? Do the appliances exist if the gas undertakings would use them? Or is it that we have not at present the appliances suitable for meeting the competition of other illuminants?

Gas in Industry.

Turning to the use of industrial gas, we might perhaps take particular note of the remarks of Colonel W. M. Carr in his Paper to the Royal Society of Arts in May last: "Having regard to the abundance of cheap electricity, water power, extensive oilfields, and supplies of natural gas in many parts of the United States of America, together with cheap coal in the Eastern States, it is significant that the use of gas by 16 million consumers is approximately *nine times* as much per consumer as is the consumption by 11 million consumers in Great Britain." And Mr. N. T. Sellman, in his Paper to the World Power Conference in Vienna this year, stated that of these 16 million American consumers who use gas, 9 million are supplied with manufactured gas and only 7 million with natural gas.

The observer naturally looks for the causes of this discrepancy between the gas-consuming appetite of the Americans and the British, and it is suggested by Colonel Carr that there is a much better appreciation in the U.S.A. of the value of gas for industry. But appreciation is growing in this country. Mr. A. W. Smith, General Manager of the Birmingham Gas Department, has said that to-day manufacturers are admitting the futility of regarding the cost of fuel as an isolated item, and are considering it in relation to the rate of production, percentage of scrap produced, quality and uniformity of the finished product, and possible reduction or elimination of subsequent processes, such as pickling, polishing, &c. The enlightened attitude described by Mr. Smith is gaining strength, but we are still far from the American usage of industrial gas. Why is this? Should we increase the scope of the industrial gas departments still farther? Would it help if the members of the S.B.G.I. were to collaborate even more in this work than they have done in the past?

Need for a National Fuel Policy.

The whole trend of my address prompts me to deal briefly with our national fuel industry as a whole. We are told that some £40,000,000 a year is the cost of permitting the atmosphere to remain smoky, and that most of this smoke arises from the domestic chimney. It seems obvious that the nation loses heavily through permitting raw coal to be used in the domestic grate and that raw coal is fundamentally unsuited for the purpose; yet it is left to the gas, coke, and electricity industries to alter this by persuading people to change from coal to smokeless fuels—a movement which is vigorously opposed by the coal interests. In the excellent Paper read by Mr. E. V. Evans before the Royal Society of Arts last March it is convincingly argued that the Gas Industry can point to uses of electricity for which there is no economic justification when one considers the other fuels which are available. Similarly, the electrical engineer can indicate uses for which electricity stands pre-eminent. Is it not time that the waste of energy in all fuel industries caused by attempting to supply a given fuel for unsuitable uses should by some means be abolished? This may be a counsel of perfection, but the over-lapping is more often due to over-enthusiastic salesmen or commercial managers, rather than to engineers. Surely we sadly need a rational de-limitation of the sphere of use of each fuel, though I do not envy the person who might be charged with this task!

In conclusion, the necessity for the fullest co-operation and collaboration between all sections of the Gas Industry has always been stressed, and very rightly, by the leaders of the Industry, and we have all seen so recently in international affairs the advantages of consultation and personal contacts. So evident are the benefits that it is clearly unnecessary to labour them, and the S.B.G.I., its Council and Members, are fully pledged to study all common problems in that spirit. From time to time, contentious problems are bound to arise between various sections of the Industry, but surely consultation in such cases will result in decisions satisfactory to all interests.

I feel sure that most, if not indeed all, of the questions which I have ventured to cover in this address are already engaging the full attention of those concerned, but if I have been able to provoke some thought by reviewing them from my own personal angle I shall feel that my address will not have been entirely valueless.

Votes of Thanks.

Sir FREDERICK WEST said that Colonel Planck had portrayed in an exceedingly interesting way some of the activities and problems of the Industry. It had always been disappointing to Sir Frederick that despite the large amount of capital and the large number of people employed in the Industry, and the fact that 12,000,000 people benefited from their activities, yet in many quarters the Industry was looked upon as somewhat unattractive, particularly by the young man of to-day. They were considered in some quarters a decadent Industry. He wondered sometimes whether they themselves talked about gas sufficiently and endeavoured to raise its prestige and importance. Considering that they employed a considerable portion of those people engaged in the Industry, did they make them potential advocates and canvassers for gas? He felt that manufacturers and contractors lost valuable opportunities by not impressing upon their staffs and employees from time to time the need for maintaining the prestige and importance of the Industry. Continuing, Sir Frederick recalled the case of a Cambridge Undergraduate who had been sent to him to gain some practical experience of gas manufacturing processes. Almost the first words Sir Frederick addressed to him when he came into his office were: "I suppose when you told your friends at Cambridge where you were going your standard, which was pretty high, fell considerably." He had replied that this was perfectly correct. That was a true illustration of the outlook of many young men at the present time. One of the most valuable functions they could perform as members of the Society would be to do all they could to remove the general idea that the Gas Industry was unattractive. Colonel Planck had touched upon several points which had engaged the attention of various organizations in research, education, and public lighting. These matters were engaging the attention of The Institution of Gas Engineers and the National Gas Council. The co-ordination of research was, indeed, engaging the attention of the whole Industry to-day. There had been a survey of present activities, and the problem was to co-ordinate them into one central research organization in order to make them more effective. If the Society were to play their proper part in this problem in its wider sphere it might mean they would have to contribute more generously than they had done in the past. There was no doubt that a large sum had been spent on research by the research organizations which existed to-day and by the manufacturers themselves. But there was still tremendous scope for research on various problems, and if they played their proper part as members of the British Gas Federation in that work he felt they would be called upon to support that greater effort much more generously than they had in the past. He had been interested to learn the previous day from Sir David Milne-Watson at the meeting of the B.G.F. of the large sum which had been raised to put the Gas Industry in its proper place in the South Kensington Museum. The S.B.G.I. set out to raise £5,000. Their past-Chairman had put in a great deal of spade work to get members to contribute generously to that fund. Sir David Milne-Watson had stated that they had already reached the sum of £6,000. That showed that the Society could take their proper place in this organized effort. Of the £20,000 they were endeavouring to raise, £19,000 had been promised.

Mr. ERNEST WEST said it was a great privilege and pleasure to him to propose that a very hearty vote of thanks be ac-

corded to their Chairman for his excellent Address. Colonel Planck had quoted the old saying that onlookers saw most of the game; but there surely must be another old saying to the effect that what the onlooker saw was coloured by the spectacles he wore. Now Colonel Planck's spectacles were deeply tinted by many years of successful business, and they were quite sure that whatever he said about the Gas Industry, or anything else to which he had taken the trouble to turn his careful attention, would be worth hearing. He had practically covered the whole field of the principal general problems which were before the Gas Industry to-day. Those who were now considering these would do well to bear in mind what he said. For instance, the question of co-ordination and extension of research, particularly with a view to widening the basis upon which it rested was, as they were aware, now under consideration. Another question upon which Colonel Planck had touched was that of the lack of statistical information available to the Industry. Of course, they had "Technical Data on Fuel," issued by the World Power Conference; but it must be admitted that, considering the immensely important position which the Gas Industry of Great Britain occupied in relation to the Gas Industry of the world, their supply of standard text-books and standard data books was very far in arrears. Their American friends were in a much better position with their Gas Engineer's Handbook and their Gas Chemist's Handbook, both prepared and kept up-to-date, it should be noted, by Committees of the American Gas Association, to say nothing of Professor Morgan's excellent text-book. Something should be done about this, suggested Mr. West, in the very near future. Continuing, Mr. West observed that Colonel Planck had referred to the want of an agreed common policy throughout the Industry with regard to the sale of coke. No doubt it was desirable that coke, as well as gas, should be so prepared and marketed that it came up to an agreed standard of quality, cleanliness, and also freedom from dust, so that a constant and regular supply was available. It should be borne in mind, not only with regard to coke but with regard to gas also, that the world was so small nowadays that an unsatisfied complaint in one district had a detrimental effect on the reputation of gas and gas coke far beyond the boundaries of that district. But it was impossible to go over anything like all the points with which Colonel Planck had dealt—the position of coke in the economy of the Industry, the necessity for the architect to be consulted in the application of gas to the new house, the need for a national fuel policy—all these and many more important questions had been touched upon in his Address, and they felt sure, in thanking him as they most cordially did, that what he had had to say would be carefully noted in those quarters where the policy of the Industry was shaped.

Mr. R. J. ROGERS, seconding the vote of thanks to the Chairman, said that Colonel Planck had reminded them of the many changes which had taken place in the Industry during the lifetime of the Society. Notwithstanding the progress that had been made, Colonel Planck had emphasized that there was still scope for development. He had reminded them of the importance of co-operation in the Industry, a subject which had been stressed by Chairmen of the Society for many years past—and, he thought, quite rightly. It was refreshing to listen to an Address such as they had heard that day. Colonel Planck had shown himself to be a keen observer of the problems confronting the Industry at the present time.

The vote of thanks was carried with acclamation and briefly acknowledged by Colonel PLANCK.

The meeting terminated with a cordial expression of thanks to Sir Frederick West for occupying the chair—on the proposition of Mr. W. H. BENNET, seconded by Mr. D. M. HENSHAW.

LUNCHEON SPEECHES.

Sir FREDERICK WEST presided at the luncheon which preceded the Autumn General Meeting. The toasts were informal.

Mr. F. B. RICHARDS proposed the health of the Chairman. There was no one, he said, whose health he would rather propose than his old friend, Sir Frederick West. It was peculiarly fitting that Sir Frederick should be in the chair that day. He was the second Chairman of the Society, following Mr. Charles Clare in 1910-11, and it was appropriate that at a moment when he was a Vice-President of The Institution of Gas Engineers he should come back and be deputizing for their President. They hoped and believed that a few years hence he would fill the highest office which it was given to members of the gas profession to occupy—President of The Institution of Gas Engineers. They on the "left-hand" side of the Gas Industry—and they did not minimize the importance of the "left-hand" side—counted it a very great honour that one of their number had been invited to fill that high office. They assured Sir Frederick that he could rely on the personal and collective support of every member of the Society.

With Sir Frederick occupying the position he did in the Institution their progress would be along sound lines. Everyone knew Sir Frederick's keen interest in education. The future of the Industry depended largely on education, and they would feel that the cause of education in particular was going to have a very good showing so long as Sir Frederick was exercising his influence in high places.

A Friendly Rival.

Sir FREDERICK WEST said that, if he had been entrusted with the selection of someone to propose his health he would have chosen Mr. Richards. He thought of him not as his enemy but as his friendly rival, and the longer they were rivals the more he valued their personal friendship.

He could not attempt to impersonate their President; therefore he could only speak to them as "Fred. West." Taking the chair on that occasion reminded him of 28 years ago when he occupied the same position as their Chairman. It reminded him also of another fact which made it peculiarly appropriate that he should be in that position—namely, that he had this year celebrated his Jubilee in the Gas Industry. In September last he completed fifty years with the firm of West's, and he looked back upon those fifty years with considerable pleasure.

It was always a very great pleasure to take part in a less active way in the proceedings of the S.B.G.I.; and, looking up the Rules of the Society, he found that the second was "To promote reciprocal good feeling and mutual confidence between gas-works contractors and manufacturers and gas authorities and officials." In other words, co-operation and working together. Many interesting matters had come before the Society in the last 33 years, and the contributions they had been able to make to the solution of many problems and the light they had been able to shed on many investigations were not the only advantages they had reaped. The feeling they had created among themselves was one from which they all benefited and by which the Industry itself benefited.

He would like to make one criticism if they would forgive him, went on Sir Frederick. One of the things on which they prided themselves was the line of distinguished Presidents they had secured. They had, indeed, been the envy of all the organizations in the Industry. If they valued their Society, if they admired their Presidents and acknowledged the value of their Chairmen's work and Addresses, then it was up to them to support the business meetings much better than they had sometimes done in the past.

Chesterfield's Central Heating Load

In Chesterfield Mr. Harold Davies, Engineer and Manager, informs us that the Gas Department supply gas to fire central-heating installations in eleven schools, a gymnasium, and a swimming bath, all of which are under the control of the Education Department.

The total maximum consumption of these schools is over 200,000 cu.ft. of gas per hour, and the price charged is 3d. per therm, less 5% discount.

Amalgamation and Grouping

United Kingdom and Ellesmere Port.

Ellesmere Port Council has now confirmed the sale of their Gas Undertaking to the United Kingdom Gas Corporation, Ltd., for £120,000.

London and Counties Coke Association

Seventh Annual Meeting

The Seventh Annual Meeting of the London and Counties Coke Association was held at the May Fair Hotel, W. 1, on Monday, Oct. 31—the PRESIDENT, Mr. Frank H. Jones, M.Inst.C.E., in the chair.

The minutes of the previous Meeting having been confirmed and signed, Mr. R. W. FOOT proposed the re-election of Mr. Jones as President of the Association. In doing so, he expressed the pleasure and honour they felt that Mr. Jones had consented to fill the position and referred to the strong support which he gave the Association.

The proposition was seconded by Mr. S. E. HALLIWELL, who said that Mr. Jones had their fullest confidence and respect.

The resolution was carried unanimously, and Mr. JONES briefly returned thanks.

Mr. FOOT thereafter presented the Annual Report and Accounts.

After discussing in detail the accounts of the Association for the year, and the satisfactory position which they revealed, Mr. FOOT gave a review of the year's work, from which the following are excerpts:

The accounts which I have now dealt with are concerned with a very active and very satisfactory year in every way. The Central, Executive, and Finance Committees have been busy all through the year, and from my personal knowledge of their work they could not bring to it a greater desire to do the very best possible for the Association and the general body of members.

Approved Appliance Catalogue.

The Technical Committee under Mr. H. C. Smith does excellent work all the time, and their crowning triumph this year is, with the co-operation of the Advertising Committee under Mr. W. J. Sandeman, aided, I know, by the personal enthusiasm and skill of the General Manager, the production of what is modestly called "the Approved Appliance Catalogue," and which might well be called "The Coke Salesmen's and the Coke Users' Bible." It really is a first-class production—the result of 7 years' good work—and it is something of which the Association as a whole may justly feel proud.

The Advertising Committee has been successful in producing a series of Press advertisements, posters, and pamphlets of a quality far in advance of anything the coke trade in this country has seen before, and it is a great tribute to the friendship and goodwill which exists to-day between producers and distributors that all the advertising matter has been approved at meetings at which the Distributors' Branch has been officially represented.

The County Committees and the joint County Meetings have carried out their important functions most successfully with the consistent help of the County Advisers, and throughout the year the Distributors' Branch, with its 4,000 members, has become completely and closely organized, thanks to the good work of the Distributors' Central Committee, under the able chairmanship of Mr. John Charrington and of the various County Committees, and thanks also to the consistently good work of the Secretary of the Branch, Colonel Flowers.

Final Test of Success.

All that I have said with regard to our organization I believe to be completely true, and still the individual member of the Association is justified in being dissatisfied unless the job he wants done *is* being done for him successfully. What is he entitled to expect? A good and steady market for his coke at fair and controlled prices, good relations with his merchants, an extended demand for coke for various purposes, and efficient technical service whenever he needs it. In other words, his question at any particular time is entitled to be—"Can I dispose of all the coke I can produce at a price which will pay me as compared with making water gas?" The answer to this question is to be found in the figures of coke sold—the final test which is the real focus of the success of the Association's work. Last year our members sold 400,000 tons more than in the previous year, and this year the total was increased still further by 100,000 tons—representing far and away the highest tonnage of coke produced and sold in the area since the Association was formed and probably for all time. And there seems no reason for thinking that the current year will show a different picture, as the price level remains, generally speaking, the same as last year, and contracts for the full quantities available have been freely sold.

There are one or two other matters of importance to which reference should be made.

Extensions of Area.

In the first place important extensions to our area were either made effective or were planned during the year. We were very pleased to welcome back the important counties of Oxfordshire and Cambridgeshire, and I would like to thank Mr. Caton and Mr. Rioch for the great help which they gave in organizing these areas and to extend to them personally a very hearty welcome to the Central Committee.

Then further west a completely new area has now been organized, to include Bristol, with part of Gloucestershire and north-east Somersetshire and the county of Wiltshire. It includes several undertakings of importance, and in particular Bristol, Bath, and Swindon. Membership within that area is nearly 100%. Mr. Halliwell, Chairman of the County Committee and the member for that area on the Central Committee, with Mr. Whimpster, of Bath, and Mr. Chester, of Swindon, the County Advisers, have all co-operated with us and given great assistance in adding this important area to the Association. Plans are now afoot for organizing the counties of Devonshire, Dorsetshire, and the rest of Somersetshire as part of the Association, and there is every prospect that the arrangements there will be completed in an equally satisfactory way.

It is possible, too, that the county of Cornwall will in due course feel that they will be better in the Association than outside it, and naturally we would welcome them into our ranks. When we get to that point our area will be bounded on three sides by the sea and on the fourth side (the north) by the new Midland Association—and then we shall have finished.

In all this great area we shall control practically the whole of the coke production. In our original area we control 99·23% of the production, and in our new area, including Oxfordshire, Cambridgeshire, and Bristol and district, we control 98·63%, representing a total production of 3,646,000 tons.

I have referred to the fact that our northern boundary now meets the recently established area of the Midland Counties Coke Association. I am glad to be able to report that this Association is definitely established on very similar lines to ours, and on your behalf I would like to wish it every success. We recently had an official meeting between the Executive Committees of the two Associations, and I am quite certain that we shall establish without any difficulty very close co-operation and co-ordination.

Coke Salesmen's Circle.

During the year the arrangement with the Association of Heating and Ventilating Engineers for the joint working with regard to gas as well as to coke has been satisfactorily completed and is working very well. There is a great advantage to both parties in this arrangement, and I hope that those few of our members who have not yet signed the agreement, thereby entitling themselves to the benefit of the arrangement, will realize that by coming into the arrangement they stand to lose nothing and to gain a very considerable business advantage.

I would not like to omit a reference to the Coke Salesmen's Circle, which has continued its function successfully during the year with a membership now of 121. Joint meetings have been inaugurated during the year between our Circle and salesmen from members of the Distributors' Branch, and these meetings have added considerably to the interest and value of the discussions. There is no doubt that the Circle is valuable to us in forming a most useful training ground for our coke salesmen, and I hope that all our members will give their coke salesmen every opportunity to take full advantage of it.

Looking Ahead.

Every year since the Association was started, there have been one or more major difficulties to contend with. Because they have been successfully met and are now behind us does not mean at all that we should become less active or in any sense rest on our oars. We have to keep our organization for price control completely watertight. We have to maintain our technical service and salesmanship up to its present high standard, thinking all the time in what further ways, by what new processes, or for what additional purposes coke can be used, and always we must be active in making quite certain that the merchant gets a fair deal and that the consumer gets the right quality and size of coke for his particular requirements. It is impossible to exaggerate the importance of this last point. More and more it looks as if

the best coke market for us in future will be the domestic boiler and the open coke grate, with particular emphasis on the latter. There is no doubt that, generally speaking, the coke produced in the South of England is the right sort of coke for this purpose, provided—and this is an important proviso—that cleaning and sizing are carried out to ensure satisfactory performance in the open grate—a performance which, it is important to remember, is carried out in full view of the consumer.

Another important reason for the Association to keep active and enterprising in all these directions is that in the work which we are doing we are not only providing openings for our own production of coke, but all the time we are finding new extensions of the coke market in the South, making-room for the surplus coke from the North to be absorbed in our area at properly regulated prices.

In conclusion, I would like to say that with the spirit of co-operation and goodwill which exists to-day between the various members of the Association and between the Association and the Distributors' Branch and also between the Association and all those other organizations with which we maintain friendly contacts, we have every reason to look forward to the future with confidence.

Mr. FOOT then formally moved the adoption of the Report and Accounts, which was seconded by Mr. S. E. KNOWLES (Eastbourne) and carried unanimously.

The GENERAL SECRETARY (Miss C. A. Wooster) then read out the County nominations.

On the proposition of Mr. F. A. GULLAND (Maidstone), seconded by Mr. W. J. SANDEMAN (Croydon), the Association's Auditors (Messrs. Cash, Stone, & Co.) were re-appointed.

On the proposition of Mr. W. PHILLIPS (Luton), a hearty vote of thanks was accorded to the Chairman of the Central Committee (Mr. R. W. Foot).

In reply, Mr. FOOT said that the Association was to-day on a really strong and broad foundation—and that was a matter for greater satisfaction to all of them than the fact that they thought they had an efficient Chairman. There was a time when a few of them were carrying a very great burden, but now, thanks first of all to their Committee work which was spread right through the area and thanks also to what was done in the Counties and to a more complete understanding of their policy throughout the Counties, and thanks also to the distributors and the way they did their job and to the goodwill which had always been apparent between members and distributors they had a foundation that nothing could destroy. Their organization was there and it was there to stay. Seven years ago they had nothing; they had plans, but that was all. They had no staff. To-day they had a staff, which he did not think they could improve upon, and he would like to thank them all very much on behalf of the members for the work they had done during the past year.

Miss WOOSTER and Mr. W. L. BOON briefly acknowledged the vote of thanks, and the proceedings then terminated.

SEVENTH ANNUAL LUNCHEON.

Preceding the Annual Meeting of the Association, the Seventh Annual Luncheon was held at the May Fair Hotel, the PRESIDENT, Mr. Frank H. Jones, M.Inst.C.E., in the Chair.

Sir DAVID MILNE-WATSON proposed the health of "The London and Counties Coke Association." He said how delighted they were that Mr. Frank Jones had accepted the Presidency of the Association, and they wished him well in his year of office. He followed a very great man in Dr. Charles Carpenter—an outstanding man in his line, whose contributions to the Gas Industry had made history.

Continuing, Sir David observed that there was a peculiar fitness—whether premeditated or not—in the fact that he was proposing the toast of the Association that day. This was the Jubilee year of organization in the British coke industry. It was in 1913 that the London Coke Committee—in which he himself had a very great personal interest—was formed. That Committee was not concerned, as was their Association, with marketing, but it tackled the problems of quality, grading, and research which then faced the Industry. In the twenty-five years since then a very great deal had happened—and here was the London and Counties Coke Association, an outstanding successful instance of what could be done when members of an industry put their heads together to solve their commercial and technical problems in a broadminded way.

Smoke Abatement.

The orderly marketing of coke was a key problem for each of the two sides of the Industry—the producers and the distributors—at the present time. The first reason for this was the greatly increased interest which was being shown in the question of smoke abatement. Up and down the land, among civic leaders, medical officers, and experts of every kind, there was growing a greater determination that something really must be done about smoke. The Minister of Health a week or two before held out a very friendly hand to the Gas Industry on the ground that its two smokeless fuels—gas and coke—"pointed the way towards the day when their cities would be as smokeless as the cities of ancient Greece;" and the Minister spoke in strong terms of the waste of energy and destruction of amenity which still went on through the same misuse of coal. Then there was Mr. Herbert Morrison, Leader of the London County Council, who uttered a call for a more determined national policy on this question, and said that his own Council was now engaged in tests of the practical possibility of installing smokeless fuel systems in the dwellings which the Council itself erected. Again, only a few days before, Mr. Morrison wrote a very striking article in the London *Star* not only reiterating his expression of the Council's hopes for a smokeless London, but appealing directly to individual citizens to change their own habits. Mr. Morrison wrote: "My advice to you is—go and make some enquiries. Ask your supply companies; ask the man who sells you coal whether he has not something else to suggest. If your fireplace won't burn anything else, and if you do not own your own house, go and tackle your landlord." On another day the previous week Sir Ernest Simon, one of the nation's authorities on housing and a former Lord Mayor of Manchester, having attacked the smoke evil, expressed the opinion that the whole problem came down to the fact that "the Gas Committee of Manchester and Salford were not selling enough gas." Sir David suggested that when Sir Ernest Simon said "gas" he meant "gas and coke;" but, whether he did or not, there was no doubt whatever that when they in London thought of smoke and thought of increased sales of their products as a way of combating smoke, they meant gas and coke.

Conservative People.

The London householder and his wife, went on Sir David, were conservative people. They would not readily give up their solid fuel fire. If the prospect of smoke abatement depended upon the chances of converting London to a love for gas and electric fires, he thought one would feel less optimistic about the chances that the Minister of Health and Mr. Herbert Morrison and other people were going to realize their hopes. But coke offered the best of both worlds. Smoke abatement in London was coming—it might be coming quicker than many of them realized. Its coming would bring an enormously increased market for gas and coke. And he would say to the distributors that in coke, in their alliance with the Gas Industry to widen the coke market, lay their own guarantee that smoke abatement, which would come to bless London, would not in any degree come to blight their business.

There was another point. Not only was coke an essential element in their programme for cleaner cities, but it was also in a financial sense one of the two legs with which the Gas Industry marched. If they wanted to keep going smoothly along, and to increase their speed, if they did not want to be reduced to the expedient of hopping along on the leg they needed a good market for coke. While that good market existed, the Gas Industry would be able to sell its therms of gas cheaply; that was what the producers must remember. The distributors would not forget that while this good market for coke was maintained the Gas Industry would be encouraged to produce it in as large a quantity as possible. Here, then, was an interlocking of interests which was the best possible basis for a continuance of that co-operation which their Association expressed.

Mr. FRANK H. JONES thanked them for the manner in which the toast had been accepted, and Sir David Milne-Watson for the kind words he had said about his predecessor in the Presidency. He had worked with Dr. Charles Carpenter and knew him very well, and although he was of a retiring nature and did not care about appearing at such functions as that, he had the work of the Association greatly at heart.

Many responsible people had affirmed that the Coke Association was good and that it had got to continue, and lately they had been saying that they could not get on without it. The Association would not have achieved the great success it had done without Mr. R. W. Foot as Chairman. By his strong personality and the kind way he did things he had guided the Association through its seven years of existence in a way that would not have been possible without him. The Association—though still in its infancy—had done great work, and it would do much greater work in the future. He could remember the time when coke was very cheap; but the Association had insisted on the producers in its area making a proper article, so that the public had a better fuel than any other—except, of course, gas.

Mr. R. W. FOOT said that it was a very great pleasure to propose the toast of "The Guests." They in the London and Counties Coke Association from the very beginning decided that they would be making a great mistake if they tried to live to themselves alone. This was a red-letter day for the Association because they had sitting side by side Mr. F. H. Jones, Sir David Milne-Watson, and Mr. Henry Woodall. It might be a surprise to them to know that these three gentlemen, through the companies they controlled, were responsible for 2,700,000 tons of coke, equivalent to 79% of the coke in the Association. That was a matter of great satisfaction to everybody, including the distribu-

tors—to know that they had the backing of those three gentlemen and all the Companies they controlled. They had had their support from the beginning and they knew they would receive their support to the end.

Mr. HENRY WOODALL, responding to the toast, said it was a very great pleasure to him to be with them on that occasion and to meet so many happy, contented, and satisfied people. Their Chairman had spoken of their distinguished guests—and had included him. Actually, he took the greatest possible interest in the Association and would continue to do so. He was proud of the small part he played in its inception, and he felt they had always continued along the right lines. The best basis for success was to give value for what one received, and that was what the Association was doing. It had never tried to raise the price unduly. He was a producer and supplier of coke in a foreign country, and there, in spite of strong protest, the price a year or so ago was raised to a very high figure; to-day they were suffering a severe slump. That was what happened when prices were increased above the rate they should be.

Mr. J. CHARRINGTON, Jnr., also responded to the toast on behalf of the Coke Distributors' Central Committee, who were present for the first time as guests. It was the first occasion on which they had had the whole of the Central Committee with them, and by the way they had turned out they had answered the Association's invitation more eloquently than he could. This was indicative of the co-operation they had tried to bring about. He was confident that the relations between producers and distributors was growing better and better all through the area. Mr. Foot had expressed the wish that the distributors should have a straight deal; so long as Mr. Foot was Chairman of the Association they were certain of one. Although others had done a very great deal for the Association, it was Mr. Foot's personality which was the foundation and the success of the whole organization.

They had received notification of a new advertising campaign featuring "New King Coke." Mr. Charrington was not sure whether a more apt slogan would not have been "New Queen Coke." But, in any event, the "Ace of Coke" was Mr. Foot!

Mr. H. C. SMITH said it was his privilege to ask them to pay a personal tribute to their Chairman, Mr. Jones. Their President really knew a great deal about the Association, and those who had something to do with the running of the Association must take it as a compliment that he left it to them to run it—though he knew very well how they were doing it. He was always ready to give them his advice.

Berwick and Tweedmouth Gas Order

An application for a Special Order under Section 10 of the Gas Regulation Act of 1920, whereby the Berwick and Tweedmouth Gas Light Company, Ltd., sought statutory powers and the application of the thermal method of charge, was the subject of enquiry at the Westminster Offices of the Board of Trade on Wednesday, Oct. 26, by Mr. R. L. Sich. The application was made in pursuance of the requirement by the Board of Trade that the Company should do so, that requirement being made under Section 9 of the Gas Undertakings Act of 1934. The system proposed for the control of dividends and prices was the basic price and dividend system.

The Company was represented by Mr. H. Royston Askew, and Mr. A. W. White, F.C.A. (of Messrs. Cash Stone & Co., Chartered Accountants) gave evidence as the Company's adviser. There were objections by the Berwick Corporation, represented by Mr. E. J. C. Neep; Mr. Arthur Valon (Messrs. W. A. Valon & Son, Consulting Engineers) was present as adviser. The Corporation asked that the sliding scale system should apply to the Company or, failing that, that the basic price proposed in the Order should be reduced. Various other matters of detail were also the subjects of objection.

Mr. H. ROYSTON ASKEW said that the Company was constituted in 1844, and had supplied gas to the inhabitants of Berwick for nearly 100 years. The gas made in the year ended April 30, 1938, was 71 million cu.ft., and the Company had supplied 3,047 consumers. For some years the price of gas to ordinary consumers had been 4s. 2d. per 1,000 cu.ft. (equivalent to 10d. per therm), less certain discounts, according to the scale of consumption; but on Oct. 1, 1938, in view of the recent increases of costs, the Company had been reluctantly compelled to raise the price to 4s. 6d. per 1,000 cu.ft. (equivalent to 10·8d. per therm), which was a very reasonable price for an undertaking of its size. The calorific value of the gas was 500 B.Th.U. per cu.ft. The capital of the Company was only £39,100, all in ordinary shares, representing approximately £550 per million cu.ft. made, which was a low figure as compared with those commonly found in undertakings of its size. The relatively low capitalization was a very good indication of prudent management, which benefited consumers and shareholders alike. It was clear that the consumers had benefited and were still benefiting from the careful way in which the Company had been carried on. The authorized capital in 1893 was £12,000 and the capital issued at that time was £10,860. From then until 1924 the value of the undertaking had appeared in the balance-sheets at the nominal value of £10,860; but in 1924 the works and plant were valued and it was shown that the issued capital did not represent the real value of the undertaking, and it was decided to capitalize undistributed profits. In 1927, £21,720 of undistributed profits was capitalized, and in 1935 there was a further capitalization of £6,500, making the issued capital £39,100. The authorized capital was £40,000, so that £900 remained unissued. There was no debenture debt and no mortgages. For some years the Company had paid dividends of 5½% free of tax on that very reasonable capital. The Order now asked that the capital authorized should remain at £40,000, and that there should be borrowing powers to the extent of half the share capital issued, which was the common provision.

The Order provided also that the basic price should be 10·5d. per therm, there being the usual clause for revision of the basic price. It was proposed to empower a differential charge of not more than 5d. per 1,000 cu.ft. beyond the inner part of the Company's limits of supply, that inner area comprising the part of the borough of Berwick within a radius of 1¼ miles from the Town Hall. The Corporation suggested that the inner area should be extended to within a radius of 1⅝ miles from the Town Hall.

In Breach of the Rules.

Mr. NEEP said he wished to raise objections with regard to the allocation of funds and the amount of interest to be allowed on borrowed money.

Mr. ASKEW replied that the clause dealing with the reserve and renewal funds was in the common form. The purpose was to split up the funds already created by the Company into the reserve and renewal funds. He pointed out that there were no references to that matter, or to the permitted interest on borrowed money in the objections lodged by the Corporation, although the Application for the Order had been before the Board of Trade for a good many months.

Mr. SICH said he was always unwilling to exclude representations, but at the same time he supposed Mr. Neep was in breach of the rules.

Mr. NEEP said that technically that was so, but he did not think the reference to the points mentioned would embarrass the Company.

Mr. ASKEW said he would not be embarrassed; it had been admitted that reference to the matters mentioned was not in accordance with the rules, but he did not want to press his objections too strongly.

Although, he continued, three local authorities were entitled to raise objections to the proposals of the Order—they were the Borough of Berwick-on-Tweed, the Rural District Council of Norham and Islandshires, and the Northumberland County Council—only the Borough of Berwick had raised objections. It was submitted by the Corporation that the interests of the consumers would be better served by providing for a standard price system with a dividend varying according to whether the price charged for gas was above or below the standard price, rather than to apply the basic price system. Mr. Askew pointed out that the basic price system had been the subject of exhaustive discussion during the last few years in Parliament and outside, and as the result of those discussions it had been re-affirmed. The last occasion was in 1937, when it was considered by the Joint Committee of both Houses of Parliament dealing with gas prices, and the Committee's opinion was that the system should be continued. The Corporation suggested that on account of the moderate size of the Berwick Company's undertaking the basic price system should not be applied to it. That, however, was not the practice of the Board of Trade, and there were many cases in which the system had been applied to undertakings of equal size or smaller.

Then the Corporation urged that, if the basic price system were applied to the Berwick Company, the basic price of 10·5d. per therm was proposed in the Order was excessive, and should be reduced. Mr. Askew pointed out that a considerable time had elapsed since the Order was deposited, that costs had risen since, and that a higher basic price would be justified under present conditions. If the Company were depositing its Order to-day it

would have asked for a higher figure. The Corporation had pointed out that the price charged for gas was equivalent to 10d. per therm and that the basic price should be less than 10d. But, in fact, the price charged had been raised to 10·8d. and the basic price asked for, of 10·5d. was less than the present selling price.

An additional reason given for a reduction of the proposed basic price was that Parliament did not allow so high a dividend on bonus capital as upon that which had been subscribed in the ordinary way. Counsel said he did not know a precedent, but in any case there were three factors which differentiated the present case from any in which such suggested practice would be said to apply. First, no such practice had ever been applied in relation to a basic price company; secondly, the Berwick Company was not voluntarily seeking further powers for itself, but was promoting the Order because it was required to do so by the Board of Trade; and thirdly, Parliament and the Board of Trade had always allowed 10% on original capital, whereas the Berwick Company asked for a basic rate of dividend of only 7%. The money which was distributed as bonus shares had been available for and could properly have been distributed as dividends to the shareholders; it was the shareholders' money and in effect the shares had been subscribed in cash by the shareholders. The capital of the Company was reasonable in amount and, indeed, it was at a low figure for that size of undertaking. The rates of dividend paid were modest and the price of gas was reasonable. The Company was to have very heavy statutory obligations placed upon it by the Order.

With regard to the suggestion by the Corporation that the inner area should be delimited as a radius of 1⅝ miles from the Town Hall, instead of the 1¾ miles proposed in the Order, he said the line marking the radius of 1⅜ miles was already beyond the area of buildings, beyond the mains of the Company, and beyond the area in which the Borough illuminated the streets.

Then it was submitted that the charge should not be more than 5s. to the consumer in a case where a meter was tested at the request of the consumer and was found to be registering correctly. Mr. Askew pointed out that the clause in the Berwick Order provided for charging the consumer the cost involved in such a case, and for the cost to be met by the Company if the meter were found to be registering incorrectly. Those provisions had been inserted in almost every Order made by the Board of Trade.

Steady Increases.

Mr. *A. W. White*, who has advised the Company, gave evidence in support of the Order. Submitting a table showing details of the working results of the Company for the three years ended April 30, 1938, he said that the quantities of gas sold showed a steady increase. The expenditure on repairs and maintenance had been very low indeed during the three years, and no provision had been made for renewals. If he had been responsible for the conduct of the Company he would have increased the price of gas a long time ago and would have set aside some moneys for renewals; but in fact that had not been done during the past three years, and as a result the consumers had had the advantage of a lower price. The surplus in each of the three years covered by the table had been very small.

Mr. NEEP, cross-examining, said that only £10,860 of the total capital of £39,100 was original capital, and that the capital had been "watered" by the issue of bonus shares.

Mr. *White* objected to the use of the word "watered," and said that the issue of bonus shares in such a Company was quite normal. It did not make the slightest difference, he said, whether a shareholder put down £10,000 and asked for shares of that value, or whether he told the Company to keep £10,000 of his money and to give him shares to that amount.

Mr. NEEP pointed out that the 5½% dividend paid, free of tax, during the past five years represented a gross dividend of £7 6s. 8d.%, assuming tax at 5s. in the £1. If the bonus shares had not been issued in 1927 and 1935, and the amount actually paid in dividends during the past five years had been based on the original capital of £10,860, it would have represented a dividend of about 27%, instead of £7 6s. 8d%.

Mr. *White* agreed that it would represent such a figure, but did not agree that the Company was a very good concern from the point of view of the remuneration of capital.

Mr. NEEP, examining the details of the calculation of the basic price, said the cost of production on the basis of the accounts for the year ended April 30, 1938, was 36·05d. but the estimated cost at present was 35·08d., a reduction of about 1d.

Mr. *White* said that that was due almost entirely to the reduction in the price of coal.

Mr. NEEP pointed out that, in order to arrive at the gross cost of 55·01d. per 1,000 cu.ft. there had been added an allowance for renewal and special purposes funds (at the rate of 1½% on capital expenditure) the allowance for dividend at the basic rate of 7%, a further allowance for the difference between the basic dividend of 7% and the 7·5% dividend paid in 1938, and an allowance for the capital that had been overspent. He suggested that the 1½% proposed to be allowed for special purposes and renewals funds should be reduced to 1%; and that, having regard to the past history of the Company in respect of the remuneration of capital, there should be no allowance added for the difference between the 7% basic dividend and the 7·5% paid in 1938. If his suggestions were adopted, he said, the final figure arrived at would be 47·03d. instead of 55·01d. per 1,000 cu.ft., and the basic price should be 9·46d. per therm, which was about 1d. lower than the basic price proposed in the Order.

Mr. *White* did not agree that the amounts allotted to special purposes and renewals funds should be 1% instead of 1½% on capital expenditure; it would be quite contrary to practice; nor did he agree that there should be no allowance to bring the dividend up to the 1938 figure. He urged that, if various items were to be lopped off, regard must be had also to reduction of income due to the reduction of the price of coke, to the repairs expenditure, and so on. He denied that the increase of the price of gas on Oct. 1 had anything to do with the application for the Order.

Prepayment Charges.

Another matter discussed by Counsel was that the Order proposed to permit an extra charge of 1·8d. per therm to prepayment meter consumers, whereas the present extra charge for prepayment meters was 0·6d. per therm. If advantage were taken of the power to charge the higher figure, the Company's revenue would be increased by approximately £1,000; but it would not be income from gas sales, and, therefore, would not come into the calculation of the permissible dividend; if it were brought in, it might reduce the dividend. He suggested that a sub-clause should be inserted in the Order to provide that, if extra charges were made to prepayment consumers, there should be an appropriate reduction of basic price. Mr. White did not agree, however, and said the general experience was that the companies exercised their powers very fairly. If the income from rentals of meters were to be included in the sale of gas for the purpose of the dividend calculation, then matters for which he had given credit in his calculation of the basic price should be amended. Counsel's suggestion was unjust, he said; the only reason for increasing rentals to prepayment consumers would be that the costs of supplying those consumers had increased.

Questioned with regard to a proposal by the Corporation that the maximum interest on any borrowed capital should be 5% instead of the 6% (the latter figure being stated in the Order), he said that a fortnight ago the limitation to 5% would have proved awkward.

With regard to the provision in the Order that the amounts in the existing reserve fund and the general reserve and depreciation account should be credited to the new reserve fund, Counsel pointed out that money in the reserve fund might be used for dividend purposes. He suggested, therefore, that while it might be proper to put the existing reserve fund into the new reserve fund, the money in the existing reserve and depreciation account should go to the renewals fund. But Mr. White did not agree; the moneys belonged to the shareholders, and it was right that they should go into the reserve fund.

Mr. NEEP did not call evidence. In his address on behalf of the Corporation he said his purpose was primarily to urge that the consumers should receive fairer treatment than it was proposed to give them under the terms of the Order.

With regard to the provision that the Company should have power to make a prepayment meter charge of 1·8d. per therm, as against the present charge of 0·6d., he said it was admitted that approximately 60% of the Company's sales of gas were made through prepayment meters. One was entitled to say that the vast majority of the prepayment consumers were poor people. If the Company took advantage of the power to increase the charge it could collect another £1,000 from that class of consumer; and it seemed possible, if not probable, that there would be an increase in that direction, bearing in mind that the price of gas had been increased. Such an increase would not enter into the calculation of dividend. He suggested that, if the Company increased the prepayment charge, the basic price should be reduced in proportion or that the Corporation should have power to apply to the Board of Trade for a reduction of the basic price; in the latter event, if the Company could show that the charge was increased solely by reason of the extra cost of supplying prepayment consumers, it would have a complete answer.

The Enquiry then closed.

British Standard Specifications

Copies of the following recently issued British Standard Specifications can be obtained, price 2s., from the Secretary, The Institution of Gas Engineers, 1, Grosvenor Place, London, S.W.1:

No. 524-1938. Refined Cresylic Acid. (Superseding No. 524-1933.)

No. 814-1938. Mild Steel Drums for Lubricating Oils.

Copies of the following recently issued British Standard Specification can also be obtained, price 3s. 6d., from the same address:

No. 813-1938. Chemical Symbols and Abbreviations.

The Coke Oven Managers' Association

Presidential Address

OF

J. CURRY

Presented at the Annual Meeting held at the Hotel Victoria, London, on Thursday, Oct. 27, 1938

In making reference to the state and prospects of our industry, most coke oven undertakings have experienced during the last four years, with the exception of the last six months, an increasing demand for coke, and, during that period, many new installations were put into operation, thereby taking full advantage of the increased demand and the rise in trade. A great deal of this demand was due to the Government re-armament programme, although the various trade agreements now in operation between this country and other foreign countries have contributed considerably to the improved trade.

The iron and steel trade were very apprehensive lest the coke makers should not be able to produce sufficient coke for furnace needs. There was, however, no shortage of coke. The very reverse occurred; the coking industry was faced with a shortage of trade due to the lowering of the iron and steel import duties which caused many blast furnaces to be damped down.

Our industry suffers from these trade cycles and with so many ovens now operating at blast furnaces and steel works, in the event of any slackness at the furnaces a great deal of coke will be thrown on to the market, and, unless there is some agreement reached to regulate output and prices, such as now operate through the International Coke Cartel, the industry will be faced with cut-throat competition. You may say this is a commercial point, but it also concerns the technical manager, because, in the event of such a position arising as I have indicated, everyone will be struggling to make ends meet on reduced coke output with consequential high costs. Under such conditions, plant upkeep is not maintained at a proper standard.

We must, at all times, look to the quality of our products and not think in terms of highest yields of by-products obtainable to the detriment of coke quality. Coke is the major product, and, if the demand be for home or export trade, the quality factor should always be met. In the export market British cokes are in competition with many foreign makes, and we must dismiss from our minds that British coke is always on top. Our Continental friends have nothing to learn in the art of coke making and marketing their products in the right condition. Research in our industry must of necessity always be of paramount importance, and we are indebted to the technical staffs of the various Coke Research Committees for the very valuable work they do. As an Association, we must work in close co-operation with the various research bodies, because, as individual concerns, the larger problems of research are beyond the means and the staffs of the small undertakings.

Domestic Coke.

In 1920 we saw the beginning of the coke oven coke nut trade for home consumption, and from that time this market has steadily developed until, at some coking plants, this branch of the trade represents 25% of their total make and, in some instances, up to 100% at other plants. It has been stated that narrow ovens can produce a coke of such a size that it can be readily screened without resorting to cutting. I would suggest that for coke nuts intended for the domestic market, uniformity of size is absolutely essential, particularly with the smaller sizes, and this uniform size cannot be obtained unless the coke is cut and the grading limits narrow.

In regard to grading, the coke nut market is an international one, and, it seems to me, some international standard of grading should be generally adopted. In this country most of the screening is done over various sizes of square mesh holes, and the products are classed as $\frac{5}{8}$ in. to $1\frac{1}{2}$ in., $1\frac{1}{2}$ in. to $2\frac{1}{2}$ in., and $2\frac{1}{2}$ in. to $3\frac{1}{2}$ in., whereas our Continental competitors in the export market screen over round hole mesh of various sizes and call their products Nos. 1, 2, and 3, which seems to be a much simpler method.

Carbonizing times and the amount of coal charged per oven have undergone extraordinary changes within recent years. Much has been written and discussed as to the merits of the wide and narrow ovens. Both have many points in their favour, much depending on the situation and the ultimate market for their products. In the foundry trade in this country, and in the export market, large coke is demanded. I do not for one moment say that this demand is justifiable, but, so long as it exists—and it is considerable—it would seem that the narrow oven is limited in its sphere of operation, whereas the 20 in. oven can meet the demand in almost any required direction.

Sulphate of Ammonia.

The market for sulphate of ammonia is brighter now than was the case three years ago, and the prices at the present time do justify manufacture. With the large amount of synthetic sulphate on the market it has been necessary to turn our attention to manufacturing sulphate of larger crystals to bring it into line with the synthetic product. This can readily be achieved by various methods, but there is still some reluctance in many quarters to increase the costs of production which are incurred in making a larger crystal. As this type of large crystal sulphate is made on most Continental coke oven plants we must keep our product up to their standard or otherwise lose business. Much progress has been made in the methods of crude benzole recovery and also in benzole rectification, which has distinct advantages, and I refer particularly to the producers of crude benzole. With higher quality crude products obtainable the recovery costs have been reduced and a saving is shown in railway carriage charges. There is always a ready demand for benzole, and so long as the import duty remains it will continue to be a valuable source of revenue.

The tar and pitch markets are not as we should like to see them, although creosote and anthracene oil have helped to ease the position due to the requirements for hydrogenation. Pitch for the briquette market in this country is almost of no account. It is true that the export market has shown increasing quantities shipped during the past three years, but not to the extent that production has increased. Some pitch coke has been manufactured and marketed in competition with petroleum coke, which is always a step in the right direction, although large quantities of pitch are still being burnt as boiler fuel at very low prices. New markets are necessary; otherwise we shall often be faced with these fluctuations.

Coke oven gas for domestic use continues to make progress, and the industrial gas load is rapidly expanding. South Yorkshire has made full use of the gas grid, and I should like to see much more done in other parts of the country on similar lines.

The younger members of the Association can be assured that their interests are continually before the officers of the Association. Those in control of plants should encourage their junior staffs to attain the necessary educational and technical standard to fit them for executive posts in the industry. It is not enough that because a youth enters the industry as an analytical chemist he should remain an analytical chemist. If he shows the adaptability he should be given as much liberty as possible on the works side of the business.

Much of the matter I have referred to is of commercial interest, but complete understanding is necessary between the commercial and technical sides of any industry to ensure success. I have no hesitation in saying that our Association will continue to play its part on progressive lines in such an important industry.

Safeguarding the Slot Meter

A Development by Messrs. George Wilson

In the course of a tour last week of the busy Coventry Works of Messrs. George Wilson Gas Meters, Ltd., a device was demonstrated to us which has been foreshadowed in recent advertisements of the firm and, now in production, forms the subject-matter of their announcement in other columns of this issue. The basic object of the development is to improve the service and life of a slot meter.

It is submitted that apart from the coin attachment, which gives little trouble when well designed, the fundamental difference between an ordinary and a slot meter is the auto-valve, which has to close off each time the coins run out. The increased use of high-consumption gas appliances coupled with a decreasing lighting load means that this valve is liable to close off without warning more often than was the case previously. Concentration on the registration of small quantities of gas leads to study of the position which occurs when the auto-valve does not close perfectly, due to foreign matter on the seating or to other causes. This is likely to happen even with a new meter in stock, through particles entering the inlet pipe, or during installation, when disturbance of the service loosens rust and other impurities.

Messrs. Wilson show calculations to prove that a pressure of 2 in. W.G. on the diaphragm of a 100 ft. small high-capacity meter is equivalent to nearly 2¼ lb.; and since the travel of the diaphragm may be from 200 to 2,500 times that of the auto-valve, according to the gearing, the multiplication of the power can bring an enormous strain upon the valve mechanism.

The Compensating Valve.

Obviously the weakest link must give way, and the following failures have been traced to an imperfect auto-valve:

Cross shaft support breaking away and leaving meter out of gear.
Auto-valve lever breaking away.
Binding in the meter gearing or the attachment.
Worn crank worms.
Attachment "creep" and cash shortage.
Leaking diaphragms due to increased strain and higher differential pressure.
Top areas and flag connexions breaking away.

Messrs. Wilson have now introduced the compensating valve, whereby the auto-valve cam is allowed to travel beyond the normal limit when trouble occurs, and, instead of damaging the meter, the shock is taken by a flexible coupling which forms a link in the cam drive.

If the prepayment cam has travelled, say, 5 ft. beyond the shut-off position, the flexible coupling will give to this extent; and when further coins are inserted the coupling must return to normal before the auto-valve operates. Thus, instead of the consumer obtaining, say, 20 cu.ft. of gas for the next penny inserted there will only be 15 cu.ft. delivered, and the possibility of cash shortage is thus avoided.

Extensive tests over a period have confirmed that a faulty auto-valve cannot cause damage to the meter, or cash shortage, if the "compensating valve" is incorporated in the meter.

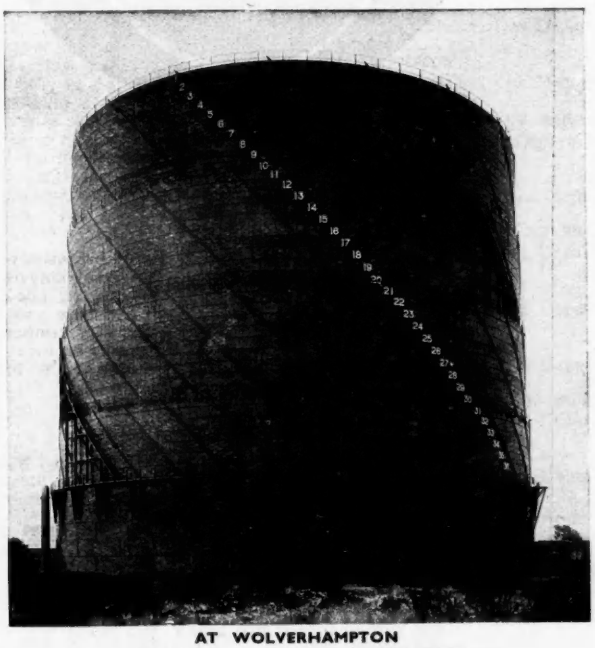
Institution of Gas Engineers

Public Health Services Congress.

Members of The Institution of Gas Engineers are invited to attend a Meeting arranged by the Engineering Public Relations Committee, of which the Institution is a co-operating member, at the Public Health Services Congress and Exhibition at the Royal Agricultural Hall at 11 a.m. on Friday, Nov. 18, when Mr. C. L. Howard Humphreys, T.D., M.Inst.C.E., M.I.Mech.E., M.Inst.W.E., M.Cons E., will read a Paper on "The Engineer's Contribution to the Public Health Services." The Chair at this Meeting will be taken by Mr. Robert Bernays, M.P., Parliamentary Secretary, Ministry of Health. This Meeting is being held on the same day as the Session sponsored by the Institution at which Miss Elizabeth Denby, Leverhulme Fellow, will read a Paper on "Smokeless Housing Schemes" and Mr. W. L. Howe, Industrial Sales Engineer, City of Nottingham Gas Department, will read a Paper on "Gas in the Service of Public Health." Members of the Institution are reminded that this latter Session is to be held at 3 p.m.

A Correction

In last week's issue we reported Mr. R. Prince (Peterborough) as saying, at the Eastern Counties Meeting, that when he was at Loughborough they had used 100% Durham coal. This should have read *Derbyshire* coal. He was also reported as saying that trouble was experienced at Peterborough if the oxygen admitted to the inlet of the purifier exceeded 1·8%. This should be 0·8%.



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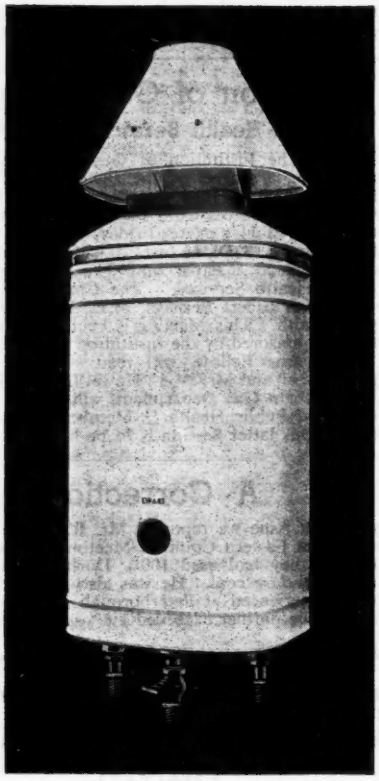

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Carew Wilson

Markets and Manufactures

Current Sales of Gas Products

The London Market

LONDON, *Nov.* 7.

There are no alterations to record in the values of Tar Products in the London market, current prices being as follows:

Pitch, nominal, at about 31s. per ton f.o.b.
Creosote, 4⅛d. to 4¼d.
Refined tar, 3¼d.
Pure toluole, about 2s. 3d.
Pure benzole, about 1s. 9d.
95/160 solvent naphtha, 1s. 7d. to 1s. 8d.
90/160 pyridine, 10s.
All per gallon naked at makers' works.

The Provinces

Nov. 7.

Crude Gas-Works Tar, 15s. to 20s.

To avoid misunderstanding, it is necessary to state that the above price is not claimed to represent a market value. It is a price worked out from week to week upon a system which has been used for many years as a basis for the fixing of certain contracts for crude tar of varying qualities in different areas.

The average prices of gas-works products during the week were: Pitch—East Coast, 31s. to 32s. f.o.b. West Coast—Manchester, Liverpool, Clyde, 31s. to 32s.* Toluole, naked, North 1s. 7½d. to 1s. 9d. Coal tar, crude naphtha, in bulk, North, 7¾d. to 8¼d. Solvent naphtha, naked, North, 1s. 4½d. to 1s. 5d. Heavy naphtha, North, 1s. 2½d. to 1s. 3d. Creosote, *ex* works, in bulk, North, liquid and salty, 4⅛d. to 4¼d.; low gravity, 4¼d. to 4½d. Carbolic acid, 60's, 1s. 7d. to 1s. 10d. Naphthalene, £13 10s. to £16. Salts, 70s. to 75s., bags included. Anthracene, "A" quality, 4½d. to 4¾d. per minimum 40% purely nominal; "B" quality unsalable. Heavy oil: Unfiltered anthracene oil, min. gr. 1,080, 4¾d. to 4¾d.; filtered anthracene oil, min. gr. 1,080 5¼d. to 5½d.; heavy tar oil, gr. less than 1.080, 4¼d. to 4¾d.

* All prices for pitch are now quoted on the basis of f.o.b. In order to arrive at the f.a.s. value at any port it will be necessary to deduct the loading costs and the tolls whatever they may be.

Scotland

GLASGOW, *Nov.* 5.

New business is still very scarce and consequently competition is extremely keen.

Crude gas-works tar.—Actual value is about 37s. to 38s. per ton *ex* works in bulk.

Pitch is quiet with plentiful supplies available at round 22s. 6d. to 23s. 6d. per ton f.o.b. for export, and about 20s. to 22s. per ton in bulk for home trade.

Refined tar is maintained in the home market at 3¼d. to 4d. per gallon, while the export price is easy at round 3d. per gallon, both into buyers' packages at makers' works.

Creosote oil.—Very few orders are being placed and prices are as under: Specification oil, 4¼d. to 4¾d. per gallon; low gravity, 5d. to 5¼d. per gallon; neutral oil, 4¾d. to 5d. per gallon; all *ex* works in bulk.

Cresylic acid.—Buying is being conducted from hand to mouth, and, competition being keen, prices are lower as follows: Pale, 97/99%, 1s. 3d. to 1s. 5d. per gallon; dark, 97/99%, 1s. 1d. to 1s. 3d. per gallon; and pale, 99/100%, 1s. 5d. to 1s. 9d. per gallon; all according to quality, *ex* works in buyers' packages.

Crude naphtha continues to command 5½d. to 6d. per gallon *ex* works in bulk, according to quality.

Solvent naphtha.—90/160 grade is available at 1s. 3½d. to 1s. 4d. per gallon and 90/190 heavy naphtha at round 1s. 1d. to 1s. 1½d. per gallon.

Motor benzole is 1s. 3d. to 1s. 4d. per gallon.

Pyridine.—90/160 grade is 8s. to 9s. per gallon and 90/140 grade is 9s. to 10s. per gallon.

Benzole Prices

These are considered to be the market prices for benzole at the present time:

	s. d.	s. d.	
Crude benzole ..	0 9½	to 0 10	per gall. at works
Motor ,, ..	1 3	,, 1 3½	,, ,, ,,
90% ,, ..	1 4	,, 1 4½	,, ,, ,,
Pure ,, ..	1 8	,, 1 8½	,, ,, ,,

Contracts Advertised To-Day

Condensers.
St. Helens Gas Department. [p. 518.]

Detarrer.
St. Helens Gas Department. [p. 518.]

Lubricating Oils and Greases.
Carlisle Gas Department. [p. 518.]

Meters.
Abertillery Gas Department. [p. 518.]

Plant Dismantling and Re-erection.
St. Helens Gas Department. [p. 518.]

Purifiers.
St. Helens Gas Department. [p. 518.]

Station Meters.
St. Helens Gas Department. [p. 518.]

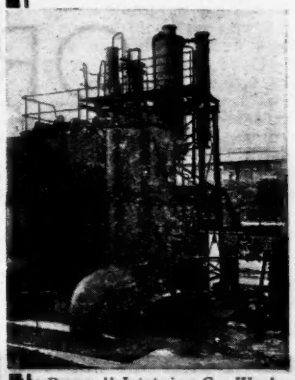
Steel Mains, Valves, and Connexions.
St. Helens Gas Department. [p. 518.]

Water Storage Tank.
St. Helens Gas Department. [p. 518.]

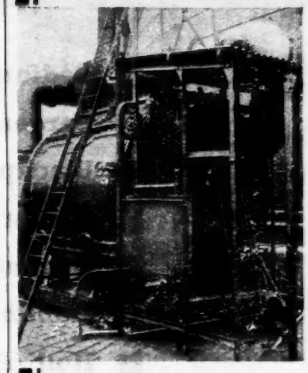
Waterford Gas Company

The report of the City of Waterford Gas Company for the year to June 30, 1938, states that the Directors have decided not to recommend the payment of a final dividend on the Consolidated stock. An interim dividend of 2½% was paid on March 1 last, and there remains a balance of £6,161 to be carried forward. Last year the final dividend was 2½%, but no interim dividend was paid.

These are "Permac" metal-to-metal Joints



"Permac" Joints in a Gas Works.



"Permac" Joints in a Gas Works.

Wouldn't it pay you to use it?

Ever since 1913 "PERMAC," the original Metal-to-Metal Jointing, has been holding up difficult joints like these in important Gas Works and on Coke Oven Plants all over the world. Equally suitable for any joint—steam, water, gas, oil—screw pipe or flange. Send for particulars.

Permac
METAL-TO-METAL JOINTING MATERIAL

Sole manufacturers:—

THOMAS & BISHOP LTD.
37, Tabernacle St.
LONDON, E.C.2
Telephone: Clerkenwell 3351 (2 lines)

REPEAT ORDERS

ARE NOW IN HAND FOR EXTENSIONS TO GLOVER - WEST VERTICAL RETORTS FOR THE FOLLOWING UNDERTAKINGS

- **Bedford**
- **Bergen**
- **Blackpool**
- **Coatbridge**
- **Coventry**
- **Dublin**
- **Hull (East)**
- **Leeds**
- **Le Mans**
- **Motherwell**
- **Oldbury**
- **Perth**
- **Romford**
- **Slough**
- **Sydney**

GLOVER-WEST VERTICAL RETORTS

. . . for coal carbonization with the advantages of modern scientific control

WEST'S GAS IMPROVEMENT CO. LTD.,

MANCHESTER: Albion Ironworks, Miles Platting ■ LONDON: Columbia House, Aldwych, W.C. 2

GAS STOCKS AND SHARES

A particularly uneventful Account came to an end last week. The tone at the close, however, was one of underlying firmness, and with more enquiries coming in during the last day or two the prospects for the current week looked more hopeful. One feature of note was the better support for British Funds, which again closed fractionally higher. The home rail market continued depressed and several ordinaries suffered a further relapse. At the opening it really looked as if the industrial section was in for a busy week, but apart from the shares of those concerns likely to benefit from rearmament the demand fell away and movements became small and irregular. The oil market was quiet but steady, several issues recording small improvements.

Business in the Gas market is slowly returning to normal, the volume last week being heavier than for some weeks past. Price movements were also more numerous, but the majority of these unfortunately were in a downward direction. Gas Light units reacted 1s. to 22s., and at the price available at the time of writing, viz.: 22s. 3d., yield a round 5%, which is a high return for the security offered. Of the Company's fixed interest stocks several closed at narrower margins. The rise of 3½ points to 140½ the previous week in Alliance and Dublin was not sustained, and the quotation dropped 5½ to 135.

Imperial Continental still continues under a cloud and eased a further 2 points, but with the European political atmosphere becoming somewhat clearer as a result of the recent debates in Parliament a movement in the opposite direction would seem more appropriate. The stock is now offered at 111 to yield 9%. Among other minor falls Commercial dropped a point to 80½, and being on offer at 81 gives the high return of £6 3s. 5d.%.

On the other side of the picture, South Suburban 3½% debenture hardened 4 to 96½, and several other small increases were recorded in the Official List, while on the Provincial Exchanges Newcastle units closed 3d. higher at 22s. 6d. For the fourth week in succession nominal quotations in the Supplementary List remained unchanged.

Official Quotations on the London Stock Exchange

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 4.	Rise or Fall on Week.
1,767,439	Sept. 5	8	8	Alliance & Dublin Ord. ...	130—140	−5½
374,000	June 20	4	4	Do. 4 p.c. Deb. ...	95—100	...
734,733	May 9	5	5	Asscd. Gas & Water U'd'ts Ord.	17/6—19/6	...
500,000	,,	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	19/—21/–	...
444,389	,,	§–/4	4	Do. 4 p.c. Red. Cum. Pref.	19/—21/–	+–/6
296,523	,,	4	4	Do 4 p.c. Irred. Cum. Pref.	16/—18/–	...
500,000	Sept. 5	3½	3½	Do. 3½ p.c. Red. Deb. ...	93—98	...
560,070	Aug. 22	7	7	Barnet Ord. 7 p.c.	157—162	...
300,000	Oct. 10	1/9½	1/4½	Bombay, Ltd.	24/—26/–	...
180,435	Aug. 22	9¼	9¼	Bournemouth sliding scale ...	195—205	...
640,407	,,	7	7	Do. 7 p.c. max. ...	152—162	...
495,960	,,	6	6	Do. 6 p.c. Pref. ...	130—135	...
50,000	June 20	3	3	Do. 3 p.c. Deb. ...	75—80	...
312,025	,,	4	4	Do. 4 p.c. Deb. ...	95—100	...
335,000	,,	5	5	Do. 5 p.c. Deb. ...	115—120	...
357,900	Aug. 8	7½	7½	Brighton, &c., 6 p.c. Con. ...	142—147	...
659,955	,,	6½	6½	Do. 5 p.c. Con. ...	126—131	...
205,500	,,	6	6	Do. 6 p.c. 'B' Pref.	120—125	...
855,000	Sept. 19	8	7	British Ord.	135—140	...
100,000	June 3	7	7	Do. 7 p.c. Pref.	140—145	...
350,000	,,	5½	5½	Do. 5½ p.c. 'B' Cum. Pref.	110—115	...
120,000	,,	4	4	Do. 4 p.c. Red. Deb. ...	95—100	...
450,000	,,	5	5	Do. 5 p.c. Red. Deb. ...	100—105	...
450,000	,,	3½	3½	Do. 3½ p.c. Red. Deb. ...	90—95	...
100,000	22 May'33	6	4	Cape Town, Ltd.	1—2	...
100,000	6 Nov.'33	4½	4½	Do. 4½ p.c. Pref. ...	1¼—3¼	...
150,000	June 20	4½	4½	Do. 4½ p.c. Deb. ...	60—70	...
626,860	July 18	6	6	Cardiff Con. Ord.	118—123	...
237,860	June 3	5	5	Do. 5 p.c. Red. Deb.	105—110	...
98,936	Sept. 19	2/–	2/–	Colombo Ord....	1⅝—1¾	...
24,510	,,	1/4½	1/4½	Do. 7 p.c. Pref.... ...	22/6—24/6	...
739,453	Oct. 10	–/11·48	–/11·48	Colonial Gas Assn. Ltd. Ord.	16/—18/–	...
296,144	,,	1/3·30	1/3·30	Do. 8 p.c. Pref. ...	22/6—24/6	...
1,775,005	Aug. 8	5	5	Commercial Ord.	78—83	1
140,000	,,	—	§13/4	Do. 4 p.c. Red. Pref.	95—100	...
620,000	June 3	3	3	Do. 3 p.c. Deb. ...	70—75	...
286,344	Aug. 22	5	5	Do. 5 p.c. Deb. ...	113—118	...
200,000	,,	—	§30/2	Do. 3½ p.c. Red. Deb.	97—102	...
807,560	Aug. 8	7	7	Croydon sliding scale ...	135—140	...
644,590	,,	5	5	Do. max. div. ...	100—105	...
620,385	June 20	5	5	Do. 5 p.c. Deb. ...	113—118	...
239,000	Aug. 8	5	5	East Hull Ord. 5 p.c. ...	95—100	...
186,155	Aug. 8	6	6	East Surrey Ord. 5 p.c. ...	116—121	...
176,211	June 3	5	5	Do. 5 p.c. Deb. ...	112—117	...
250,000	July 4	4	8	Gas Consolidation Ord. 'B' ...	19/—21/–	...
250,000	May 9	4	4	Do. 4 p.c. Red. Cum. Pref.	17/6—19/6	...
9,223,324	Aug. 8	5*	5½	Gas Light & Coke Crd. ...	21/—23/–a	−1/–
2,600,000	,,	3½	3½	Do. 3½ p.c. max. ...	78—81	+1
4,477,106	,,	4	4	Do. 4 p.c. Con. Pref....	97—100	−1
2,993,000	July 4	—	3½	Do. 3½ p.c. Red. Pref. ...	98—101	−1
8,602,497	May 23	3	3	Do. 3 p.c. Con. Deb....	76—79	−1
3,642,770	,,	5	5	Do. 5 p.c. Red. Deb....	110—115	...
3,500,000	,,	4½	4½	Do. 4½ p.c. Red. Deb....	109—112	...
700,000	Sept. 5	3½	3½	Do. 3½ p.c. Red. Deb....	93—98	...
270,466	Aug. 22	6	6	Harrogate New Cons. ...	117—122	...
157,500	Mar. 21	1/2½	‡1/–	Hong Kong and China Ord....	⅝—1	...
213,200	Aug. 8	6	5½	Hornsey Con. 3½ p.c ...	97—102	...
5,600,000	Oct. 24	12	8	Imperial Continental Cap ...	107—112*	−2
223,130	July 18	3½	3½	Do. 3½ p.c. Red. Deb....	87—92	...
235,242	Aug. 8	8½	8½	Lea Bridge 5 p.c. Ord. ...	164—169	...
11,751	Aug. 22	10	8	Maidstone 5 p.c. Cap. ...	175—185	...
63,480	June 20	3	3	Do. 3 p.c. Deb.... ...	70—75	...
45,000	May 23	†10	†10	Malta & Mediterranean ...	130—135	...
				Metropolitan (of Melbourne) 5½ p.c. Red. Deb.	97—100	...
392,000	Oct. 3	5½	5½	M.S. Utility 'C' Cons. ...	99—104	...
231,977	Aug. 22	5	5	Do. 4 p.c. Cons. Pref.	95—100	...
968,658	,,	4	4	M.S. Utility 4 p.c. Deb. ...	95—100	...
390,076	June 20	4	4	Do. 5 p.c. Deb. ...	113—118	...
148,955	,,	5	5	Do. 3½ p.c. Red. Bds.	95—98	...
125,000	July 1	3½	3½	Montevideo; Ltd.	73—78	...
675,000	May 9	†6	†6	North Middlesex 6 p.c. Con.	142—147	...
250,000	Aug. 8	7½	7½	Northampton 5 p.c. max. ...	105—110	...
396,160	Aug. 8	5	5	Oriental, Ltd.	145—150*	...
300,000	Oct. 24	†7	†9	Plymouth & Stonehouse 5 p.c.	140—150	...
468,537	June 3	8	8	Portsmouth & Gosport Cons.	157—162	...
621,667	Aug. 8	8½	8½	Do. 5 p.c. max. ...	100—105	...
241,446	,,	5	5	Do. 5 p.c. Pref. ...	107—112	...
73,350	,,	5	5	Do. 4 p.c. Pref. ...	90—95	...
75,000	,,	4	4	Preston 5 p.c. Pref.	105—110	...
114,000	Aug. 8	5	5	Primitiva 4 p.c. Cons. Deb. ...	98—103	...
247,966	June 3	4	4	Do. 4 p.c. Red. Deb. ...	94—99	...
625,959	July 18	4	4	San Paulo 6 p.c. Cum. Pref. ...	8½—9	...
15,000	Sept. 5	6	6	Severn Val. Gas Cor. Ld. Ord.	20/6—22/6	...
441,275	Sept. 19	1/1½	1/1½	,, ,, 4½ p.c. Cum. Pref.	19/6—21/6	...
460,810	Sept. 19	–/10½	–/10½	Shrewsbury 5 p.c. Ord. ...	127—132	...
133,201	Aug. 22	5	8½	South African Ord.	4½—5½	...
9,000	June 3	4	‡4	South East'n Gas Cn. Ld. Ord.	21/—23/–	...
1,371,752	Aug. 22	1/2½	1/2½	Do. 4½ p.c. Red. Cum. Pref.	19/—21/–	—/6
871,636	,,	–/10½	–/10½	Do. 4 p.c. Cum. Pref. ...	18/—20/–	...
498,818	,,	4	4	Do. 4 p.c. Deb.	99—102	...
450,000	Aug. 8	4	4	Do. 3½ p.c. Red. Deb. ...	94—97	...
150,000	,,	3½	3½	South Met. Ord.	103—106	...
6,709,895	Aug. 8	6	5	Do. 6 p.c. Irred. Pref. ...	125—130	...
1,135,812	,,	6	6	Do. 4 p.c. Irred. Pref. ...	95—100	...
850,000	,,	4	4	Do. 3 p.c. Deb.	75—80	...
1,895,445	June 20	3	3	Do. 5 p.c. Red. Deb. ...	107—112	...
1,000,000	July 4	5	5	Do. 3½ p.c. Red. Deb. ...	97—102	...
600,000	,,	—	§31/–	South Suburban Ord. 5 p.c. ...	113—118	...
1,543,795	Aug. 8	6	6	Do. 5 p.c. Pref.... ...	108—113	...
512,825	,,	5	5	Do. 4 p.c. Pref.... ...	95—100	...
500,000	,,	4	4	Do. 3½ p.c. Red. Pref. ...	90—95	...
250,000	,,	3½	3½	Do. 5 p.c. Deb.... ...	113—118	...
888,587	June 3	5	5	Do. 4 p.c. Deb.... ...	95—100	...
250,000	,,	4	4	Do. 3½ p.c. Red. Deb. ...	94—99	+4
200,000	Aug. 8	3½	3½	S. Western Gas & Water Ord.	16/—18/–	...
427,859	Sept. 19	8⅛	9⅛	Do. 4½ p.c. Red. Cum. Pf.	19/—21/–	...
160,523	Oct. 10	–/10½	–/10½	Do. 4 p.c. Red. Deb. ...	95—100	...
110,000	June 3	4	4	Southampton Ord. 5 p.c. ...	105—110	...
750,541	Aug. 8	5½	5	Do. 4 p.c. Deb. ...	95—100	...
148,836	June 3	4	4	Swansea 5½ p.c. Red. Pref. ...	105—110	...
350,000	Aug. 8	5½	5½	Do. 3½ p.c. Red. Deb. ...	93—98	...
200,000	June 3	3½	3½	Tottenham and District Ord.	125—130	...
1,076,490	Aug. 8	6⅝	6⅝	Do. 5½ p.c. Pref. ...	116—121	+1
409,835	,,	5¼	5¼	Do. 5 p.c. Pref. ...	108—113	...
62,235	,,	5	5	Do. 4 p.c. Deb. ...	95—100	...
334,615	June 3	4	4	Tuscan 6 p.c. Red. Deb. ...	95—101	...
85,701	Apl. 25	6	6	U. Kingdom Gas Cor. Ord. ...	17/6—19/6	...
1,131,550	Aug. 22	6	4	Do. 4½ p.c. 1st Cum. Pref.	19/—21/–	...
1,051,280	May 9	4½	4½	Do. 4 p.c. 1st Red. Cum. Pf.	19/—21/–	...
762,241	,,	–/1·15	4	Do. 4 p.c. 2nd Non-Cum.Pf.	16/—18/–	...
745,263	June 3	4½	4½	Do. 3½ p.c. Red. Deb. ...	95—98	...
1,066,186	Sept. 5	3½	3½	Uxbridge, &c., 5 p.c. ...	125—130	...
375,689	Aug. 8	7	7	Do. 5 p.c. Pref. ...	108—113	...
133,010	,,	5	5	Wandsworth Consolidated ...	135—140	...
1,371,138	Aug. 8	7	7	Do. 4 p.c. Pref. ...	95—100	...
2,525,768	,,	4	4	Do. 5 p.c. Deb. ...	113—118	...
1,343,964	June 3	5	5	Do. 4 p.c. Deb. ...	95—100	...
383,745	,,	4	4	Do. 3½ p.c. Red Deb.	97—102	...
400,000	,,	—	§25/–	Watford and St. Albans Ord.	128—133	...
558,342	Aug.	7	6¾	Do. 5 p.c. Pref. ...	107—112	...
200,000	,,	5	5	Do. 5½ p.c. Pref ...	110—115	...
200,000	,,	5½	5½	Do. 4 p.c. Red. Pref.	95—100	...
200,000	,,	—	16/8§	Do. 4 p.c. Red. Deb.	96—101	...
200,000	June 3	4	4	Do. 3½ p.c. Red Deb.	90—95	...
200,000	,,	3½	3½			

a.—The quotation is per £1 of stock. * Ex. div. † Paid free of income-tax. ‡ For year. § Actual.

Supplementary List and Provincial Exchanges overleaf.

STOCK AND SHARE LIST—Cont.

Supplementary List, not Officially Quoted, London

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Nominal Quotations Nov. 4.	Rise or Fall on Week.
202,152	Sept. 5	5	5	Ascot Ord.	101—106	...
128,182	July 18	5	5	Do. 5 p.c. Pref.	108—113	...
31,035	Aug. 22	-/4½	-/4½	Associated Utilities 4 p.c. Pref.	16/-—18/-	...
100,000	Dec. 13	...	3½	Do. 3½ p.c. Red. Deb. ...	95—100	...
17,000	Aug. 22	8	8	Bognor Orig. Ord. 'A' ...	155—165	...
62,210	,,	8	8	Do. New Addl. 'A' ...	155—165	...
87,160	,,	7	7	Do. New 7 p.c. max. ...	145—155	...
37,440	Aug. 8	10	10	Cam. Univ. & Town 10 p.c. max.	188—198	...
125,970	,,	7	7	Do. 7 p.c. max.	133—138	...
39,025	,,	5	5	Do. 5 p.c. max.	97—102	...
96,410	July 18	4½	4½	Cardiff 4½ p.c. Pref.	95—100	...
150,000	Aug. 8	4	4	Croydon 4 p.c. Pref.	97—100	...
130,000	June 20	4	4	Do. 4 p.c. Deb.	95—100	...
65,000	Aug. 8	8½	7½	Eastbourne 'A' 5 p.c. ...	140—145	...
198,000	,,	7	6	Do. 'B' 3½ p.c.	114—119	...
112,312	,,	5	5	Do. 5 p.c. Pref.	107—112	...
130,000	June 20	5	5	Do. 5 p.c. Deb.	112—117	...
24,000	Aug. 8	8½	8½	Great Yarmouth 8½ p.c. max.	43—48	...
59,400	,,	7½	7½	Do. 7½ p.c. max.	33—38	...
51,160	June 3	5½	5½	Do. 5½ p.c. Deb.	121—126	...
152,600	Sept. 5	9	8	Guildford Cons.	163—168	...
54,055	,,	5	5	Do. 5 p.c. Pref.	107—112	...
68,250	June 3	5	5	Do. 5 p.c. Deb.	107—112	...
156,600	Aug. 22	7½	7½	Hampton Court Cons. ...	131—136	...
80,000	Aug. 8	4	4	Lea Bridge 4 p.c. Pref. ...	90—95	...
60,000	,,	6	6	Do. 6 p.c. Pref.	121—126	...
94,876	June 3	4	4	Do. 4 p.c. Deb.	95—100	...
73,620	Sept. 5	8½	8½	Luton Cons. 'A'	153—163	...
107,960	Sept. 19	5½	4	Mid Kent Ord.	8½—9½	...
230,940	Aug. 8	10	10	Oxford & District Ord. ...	195—200	...
47,112	,,	5	5	Do. 5 p.c. Pref.	106—111	...
50,000	,,	6	6	Do. 6 p.c. Red. Pref. ...	107—112	...
126,193	May 9	7½	7½	Peterborough Ord.	135—145	...
64,990	Sept. 5	6½	7½	Redditch Ord.	118—128	...
166,850	Aug. 8	8	8	Romford Ord.	142—147	...
60,000	,,	4	4	Do. 4 p.c. Pref.	97—100	...
44,000	Sept. 19	5	5	Do. 5 p.c. Deb.	112—117	...
25,570	Aug. 8	5½	5½	Rugby 5½ p.c. Pref.	120—125	...
25,000	,,	6	6	Do. 6 p.c. Red. Pref. ...	104—109	...
42,750	June 3	5½	5½	Do. 5½ p.c. Deb.	118—123	...
110,950	Aug. 22	8	8	Ryde Ord.	140—150	...
270,086	Sept. 5	7	7	Slough Ord.	128—133	...
21,000	June 20	5	5	Do. 5 p.c. Deb.	110—115	...
28,872	May 9	5½	5½	S. Midland Gas Cpn. Ltd. Ord.	19/-—21/-	...
28,866	Sept. 5	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	18/-—20/-	...
117,228	Aug. 8	7	5	Swindon Cons.	102—107	...
60,425	June 3	5	5	Do. 5 p.c. Deb.	112—117	...
64,380	June 3	5	5	Torquay & Paignton 5 p.c. Pref.	107—112	...
130,000	Aug. 8	8	5	Wakefield Ord.	116—121	...
81,650	,,	5	5	Do. 5 p.c. max.	100—105	...
82,000	Aug. 8	6	6	Weymouth Ord.	103—108	...
98,384	Aug. 22	6	6	Wolverhampton 6 p.c. Pref.	118—123	...
160,000	June 20	5½	5½	Do. 5½ p.c. Rd. Db.	105—110	...
90,000	June 20	5	5	York 5 p.c. Red. Deb. ...	104—109	...
133,640	July 18	6½	6½	Yorktown (Cam.) 5 p.c. Cons.	118—123	...
120,000	,,	5	5	Do. 5 p.c. Pref.	105—110	...
35,000	June 3	5½	5½	Do. 5½ p.c. Deb.	120—125	...

BRISTOL EXCHANGE

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 4.	Rise or Fall on Week.
347,756	July 18	6	5	Bath Cons.	117—119	...
1,667,250	July 18	5	5	Bristol, 5 p.c. max.	112½—114½	...
120,420	June 3	4	4	Do. 1st 4 p.c. Deb. ...	100—102	...
217,870	,,	4	4	Do. 2nd 4 p.c. Deb. ...	100—102	...
328,790	,,	5	5	Do. 5 p.c. Deb.	119—122	...
274,000	Aug. 8	5	5	Newport (Mon). 5 p.c. max....	97—99	...
13,200	Sept. 19	8½	7	Pontyp'l Gas & W. 10 p.c. 'A'	12½—13½	...
13,600	,,	6	5	Do. 7 p.c. 'B'	11½—12½	...
40,000	,,	6	5	Do. 7 p.c. 'C'	11½—12½	...
140,778	Aug. 8	5	5	Weston-super-Mare Cons. ...	108—110	...
64,338	June 20	4	4	Do. 4 p.c. Deb.	100—102	...
33,340	,,	7½	7½	Do. 7½ p.c. Deb.	151—154	...

LIVERPOOL EXCHANGE

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 4.	Rise or Fall on Week.
157,150	Aug. 8	6½	5	Chester 5 p.c. Ord.	109—111	...
92,500	June 20	4	4	Do. 4 p.c. Pref.	95—99	...
36,430	,,	3½	3½	Do. 3½ p.c. Deb.... ...	87—90	...
41,890	,,	4	4	Do. 4 p.c. Red. Deb. ...	97—101	...
2,167,410	Aug. 22	6	6	Liverpool 5 p.c. Ord.... ...	121—123	...
245,500	June 20	5	5	Do. 5 p.c. Red. Pref. ...	97—102	...
306,083	July 18	4	4	Do. 4 p.c. Deb....	100—102	...
106,280	Aug. 8	10	10	Preston 'A' 10 p.c.	198—208	...
188,219	,,	7	7	Do. 'B' 7 p.c.	131—141	...

NEWCASTLE EXCHANGE

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 4.	Rise or Fall on Week.
122,577	Aug. 8	8	8	Blyth 5 p.c. Ord.	161—163	...
732,000	Aug. 22	5	5	Hartlepool G. & W. Cn. & New	89½—90½	...
2,061,315	Aug. 8	5½	5	Newcastle & Gateshead Con.	22/3-22/9d	...
682,656	,,	4	4	Do. 4 p.c. Pref. ...	99—100	...
776,706	June 20	3½	3½	Do. 3½ p.c. Deb. ...	88½—89½	...
277,285	Oct. 24	5	5	Do. 5 p.c. Deb. '43 ...	103½—105½*	...
332,351	Aug. 22	6	6	Sunderland 6 p.c. max. ...	135—136	...

NOTTINGHAM EXCHANGE

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 4.	Rise or Fall on Week.
542,270	Aug. 8	9	6	Derby Con.	133—138	—2½
55,000	June 3	4	4	Do. 4 p.c. Deb. ...	100—105	...
20,000	June 20	5	5	Long Eaton 5 p.c. Pref.	10—12	...
80,000	,,	5	5	Do. 5 p.c. Deb. ...	105—110	...

SHEFFIELD EXCHANGE

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Nov. 4.	Rise or Fall on Week.
10,000	Aug. 8	10	10	Great Grimsby 'A' Ord. ...	205—215	...
6,500	,,	10	10	Do. 'B' Ord. ...	205—215	...
79,000	,,	10	10	Do. 'C' Ord. ...	195—205	...
1,806,339	Aug. 22	6½	6½	Sheffield Cons.	140—142	...
95,000	July 4	4	4	Do. 4 p.c. Deb.	101—103	...

o The quotation is per £1 of Stock. * Ex div.

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